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# Pressure Sensitive Tape and Label Surface Coating Industry - Background Information for Proposed Standards

Radian Corp.
Durham, NC

Prepared for

Environmental Protection Agency
Research Triangle Park, NC

Aug 80

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Office of Air Quality
Planning and Standards
Research Triangle Park NC 27711

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# Pressure Sensitive Tape and Label Surface Coating Industry — Background Information for Proposed Standards

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Standards of performance for the control of emissions from pressure sensitive tape and label surface coating operations are being proposed under the authority of Section 111 of the Clean Air Act. These standards would apply to release, precoat, and adhesive coating lines which emit more than 15 megagrams (16.5 tons) of volatile organic compounds per year and for which construction or modification began on or after the date of proposal of the regulations. This document contains background information and environmental and economic impact assessments of the regulatory alternatives considered in developing proposed standards.

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# Pressure Sensitive Tape and Label Surface Coating Industry — Background Information for Proposed Standards

Emission Standards and Engineering Division

U.S. ENVIRONMENTAL PROTECTION AGENCY
Office of Air, Noise, and Radiation
Office of Air Quality Planning and Standards
Research Triangle Park, North Carolina 27711

September 1980

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ENVIRONMENTAL PROTECTION AGENCY

# Background Information
# and Draft
# Environmental Impact Statement
# for the Pressure Sensitive
# Tape and Label Surface Coating Industry

Prepared by:

Don R Goodwin 9-3-80

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1. The proposed standards of the performance would limit emissions of volatile organic compounds (VOC) from new, modified, and reconstructed pressure sensitive tape and label surface coating facilities. Section III of the Clean Air Act (42 in U.S.C. 7411), as amended, directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare." The northeastern and north central regions of the country would be particularly affected by the proposed standard.

2. Copies of this document have been sent to the following Federal Departments: Labor; Health and Human Services; Defense; Transportation; Agriculture; Commerce; Interior, and Energy; the National Science Foundation; and Council on Environmental Quality; to members of the State and Territorial Air Pollution Program Administrators (STAPPA) and the Association of Local Air Pollution Control Officials (ALAPCO); to EPA Regional Administrators; and to other interested parties.

3. The comment period for review of this document is 60 days and is expected to begin on or about September 15, 1980.

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## METRIC CONVERSION TABLE

In keeping with U.S. Environmental Protection Agency policy, metric units are used in this report. These units may be converted to common English units by using the following conversion factors:

| Metric Unit | Metric Name | Equivalent English Unit |
|---|---|---|
| | LENGTH | |
| m | meter | 39.3700 in. |
| m | meter | 3.2810 ft. |
| | VOLUME | |
| l | liters | 0.2642 U.S. gal. |
| $m^3$ | cubic meters | 264.2 U.S. gal. |
| | WEIGHT | |
| kg | kilogram ($10^3$ grams) | 2.2046 lb. |
| Mg | megagram ($10^6$ grams) | 1.1023 tons |
| Gg | gigagram ($10^9$ grams) | 1,102.3 tons |
| | ENERGY | |
| GJ | gigajoule | $9.48 \times 10^5$ Btu |
| GJ | gigajoule | 277.76 kwh |
| J/g | joule per gram | 0.430 Btu/lb. |
| | VOLUMETRIC FLOW | |
| $Nm^3$/sec | normal cubic meters per second | 2242 SCFM ($ft^3$/min) |
| | SPEED | |
| m/s | meters per second | 196.86 ft/min |

Temperature in degrees Celcium (°C) can be converted to temperature in degrees Farenheit (°F) by the following formula:

$$(°F) = 1.8\ (°C) + 32$$

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# 1. SUMMARY

## 1.1 REGULATORY ALTERNATIVES

The development of standards of performance for new, modified, or reconstructed sources of stationary air pollution was dictated by Section 111 of the Clean Air Act (42 United States Code 7411). The EPA Administrator is empowered to establish performance standards for all such industrial categories, including pressure sensitive tapes and labels (PSTL).

Regulatory Alternative I is defined as baseline control. It represents the volatile organic compound (VOC) emission level that would be allowed if no new source performance standard (NSPS) was promulgated. The control level of this alternative would be equal to the emission limits recommended by the May, 1977 Control Techniques Guidelines (CTG) entitled Control of Volatile Organic Emissions from Existing Stationary Sources - Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks. This control level would be expected to achieve approximately an 80 percent overall reduction in VOC emissions.

Regulatory Alternative II is defined as moderate control. This alternative would limit the emission of VOC from drying ovens only. No fugitive control would be required. Overall VOC emissions would be expected to be reduced by 85 percent.

Regulatory Alternative III represents the stringent level of VOC control. This alternative would control both drying oven and fugitive VOC emissions. An overall VOC emission reduction of 90 percent would be expected under this alternative.

## 1.2 ENVIRONMENTAL AND ENERGY IMPACTS

The primary environmental impact from the PSTL industry is the uncontrolled emission of VOC from coating line drying ovens. These emissions occur in both pressure sensitive adhesive and release coating operations. The uncontrolled emission of VOC results from solvent vaporization in product drying ovens and as fugitive emissions around the product coating areas. The majority of PSTL coating facilities are located in industralized urban areas. VOC emissions can potentially cause an air pollution problem because they are precursors to the formation of ozone and oxygenated organic aerosols (photochemical smog).

Nitrogen oxide ($NO_x$), sulfur dioxide ($SO_2$), and carbon monoxide (CO) emissions were examined as potential air emissions from drying ovens which use direct-fired burners. These emissions were determined to be negligible when compared to the VOC emissions. Nitrogen oxides were also examined as an emission from an incinerator control device. Tests showed that these emissions were negligible.

Steam boilers are another potential gaseous pollutant emission source for systems which use indirect, steam-heated ovens or carbon adsorption units. The boilers were not examined in this study because they are being investigated in the industrial boilers NSPS study.

An overview of the potential environmental impacts that could result from the implementation of the regulatory alternatives is presented in Table 1-1. The estimated effects shown in this table are based on comparisons between Regulatory Alternatives II and III and the base case (Regulatory Alternative I). The impacts represent changes above or below the base case. No absolute impacts are shown for any alternatives. Detailed analyses of the impacts are presented in Chapter 7, "Environmental and Energy Impacts," and Chapter 8, "Economic Impacts."

Regulatory Alternative I represents the base case. Because of this all of the impact values for this alternative are zero. There would be no impact in comparing the baseline with itself. Under Regulatory Alternative II increased reductions in VOC emissions, above that achievable by Alternative I, would be expected. The reductions would increase

## TABLE 1-1. MATRIX OF ENVIRONMENTAL AND ECONOMIC IMPACTS OF REGULATORY ALTERNATIVES

| Administrative Action | Air Impact | Water Impact | Solid Waste Impact | Energy Impact | Noise Impact | Economic Impact |
|---|---|---|---|---|---|---|
| Alternative I | 0 | 0 | 0 | 0 | 0 | 0 |
| Alternative II | +2** | -1* | -1* | +1** | -1 | -1* |
| Alternative III | +3** | -2* | -2* | +2** | -1 | -2* |
| Delayed Standards | 0 | 0 | 0 | 0 | 0 | 0 |

KEY

+ Beneficial impact
\- Adverse impact
* Short-term impact
** Long-term impact
*** Irreversible impact

0 - No impact
1 - Negligible impact
2 - Small impact
3 - Moderate impact
4 - Large impact

because the control device efficiencies under Alternative II are higher than those used in Alternative I. Alternative II controls had a control device efficiency of 96 percent while Alternative I controls were rated at only 90 percent efficient.

Table 1-1 indicates that Regulatory Alternative II could cause potential water and solid waste impacts. Water containing dissolved organics and solid carbon wastes are the primary forms in which these impacts occur. The operation of carbon adsorption control devices produces the wastewater and solid waste carbon materials. On a national basis the total quantities of wastewater and waste carbon produced would be about 9 percent above that generated by Alternative I. The magnitude of the organic pollution problem would not be serious. The severity of the problem is further lessened by the estimated reductions in the use of solvent-based coating. As solvent use declines fewer carbon adsorption controls would be needed, hence lessening quantities of contaminated water and carbon would be produced.

Regulatory Alternative III would have the largest impact on VOC emissions of all the regulatory options. In 1985 VOC emissions would be reduced by 4300 metric tons above that achievable under Alternative I. This reduction represents a 16 percent decrease in emissions above the base case.

In 1985 the wastewater discharge resulting from Alternative III control would be about 13 percent greater than that occurring under Alternative I. The magnitude of the solid waste impact would be similar to that of water. Alternative III would produce a 14 percent increase in solid waste emissions above those of the base case. These environmental impacts should decrease based on the predicted decline in the use of solvent-based coating technologies.

The extent of energy impacts under Regulatory Alternatives II and III would depend on the time frame considered. In the short-term time frame energy consumption would be higher than that required by Regulatory Alternative I. Energy in the forms of electricity, natural gas, and fuel oil would be needed to power the VOC control equipment. Nationally the PSTL industry would require approximately 3 percent more electricity, 9 percent more natural gas, and 15 percent more fuel oil than required for Alternative I control.

In the long-term time frame net reductions in energy consumption are predicted under Regulatory Alternatives II and III. In the potential best case situation for Alternative II, a national net energy savings of approximately 15,700 barrels (2.5 million liters) of crude oil exists. For Alternative III a national net savings of 27,100 barrels (4.3 million liters) of crude oil is predicted. The best case assumes all new coating lines use carbon adsorption systems to recover solvent emissions. The implementation of either Alternative II or III would provide an incentive for coaters to switch from solvent-based coating technology to alternative low-solvent coatings. Energy could be saved by the increased use of more energy-efficient coating processes and by the decline in the use of energy-consuming VOC control equipment.

## 1.3 ECONOMIC IMPACT

The proposal of any major legislative regulation requires the evaluation of all inflationary impacts and the preparation of a regulatory analysis. These analyses would be necessary if any of the regulatory alternatives being considered could cause either of the following criteria to be met:

- Total additional cost of production of any major industry service exceeds five percent of the selling price of the product.
- Additional annual costs of compliance, including capital charges (interest and depreciation), total $100 million (i) within any one of the first five years of implementation, or (ii) if applicable, within any calendar year up to the date by which the law requires attainment of the relevant pollution standard.

In the analysis performed on the PSTL industry and Regulatory Alternatives I, II, and III, neither of these criteria were met. An

NSPS based on these regulatory alternatives could not, therefore, be considered a major action. The complete, detailed economic assessment is presented in Chapter 8. The impacts in this chapter were developed on the premise that a firm (when faced with NSPS compliance) could or could not switch to alternate coating technologies (waterborne or 100 percent solid formulations) to produce their same product. This constraint had the effect of altering the impact of the regulatory alternatives on the various coating line cases.

In the unconstrained case (firms can use alternate coating technologies), none of the regulatory alternatives would have an impact on any of the coating line models. Assuming the adoption of proposed State Implementation Plan standards, firms in this category (PSTL) would have already switched to waterborne and 100 percent solids coatings. Their cost burdens would have already been incurred in attempting to comply with the SIP's. The promulgation of an NSPS based on Alternatives I, II, or III would not, therefore, present any additional cost burdens. Since the alternative systems are more profitable than conventional solvent-based systems, firms in the industry have an economic incentive to adopt them even in the absence of a regulation.

In the constrained case (firms can not use alternate coating technologies) the regulatory alternatives would have minor impacts on certain coating line situations. Under Alternative II control, product price increases of 0.0 to 0.4 percent would exist. These figures assume that the producer passes all costs for controls on to the consumer. If all costs for controls are absorbed by the producer, the industry's baseline return on investment would decrease by 0.0 to 0.6 percent. Under Alternative III control, with full cost pass-on, the product price would increase by 0.0 to 0.9 percent. Full cost absorption under this alternative would reduce return on investment by 0.0 to 1.0 percent. The large-size facilities have slightly higher impacts than the medium and small facilities.

The regulatory alternatives would have little or no impact on the industry's growth rate and structure. The availability of alternative technologies and the small price and return on investment impacts on the conventional solvent-based systems imply that the regulatory alternatives would not deter new investment and adversely affect growth. Although the large facilities would be affected more than the medium and small facilities, the difference is not great enough to put the large facilities at a competitive disadvantage. Thus, the regulatory alternatives would not cause any significant changes in the structure of the industry.

# 2. INTRODUCTION

## 2.1 BACKGROUND AND AUTHORITY FOR STANDARDS

Before standards of performance are proposed as a Federal regulation, air pollution control methods available to the affected industry and the associated costs of installing and maintaining the control equipment are examined in detail. Various levels of control based on different technologies and degrees of efficiency are expressed as regulatory alternatives. Each of these alternatives is studied by EPA as a prospective basis for a standard. The alternatives are investigated in terms of their impacts on the economics and well-being of the industry, the impacts on the national economy, and the impacts on the environment. This document summarizes the information obtained through these studies so that interested persons will be able to see the information considered by EPA in the development of the proposed standard.

Standards of performance for new stationary sources are established under Section 111 of the Clean Air Act (42 U.S.C. 7411) as amended, hereinafter referred to as the Act. Section 111 directs the Administrator to establish standards of performance for any category of new stationary source of air pollution which ". . . causes, or contributes significantly to air pollution which may reasonably be anticipated to endanger public health or welfare."

The Act requires that standards of performance for stationary sources reflect ". . . the degree of emission reduction achievable which (taking into consideration the cost of achieving such emission reduction, and any nonair quality health and environmental impact and energy requirements) the Administrator determines has been adequately demonstrated for that category of sources." The standards apply only to stationary sources, the construction or modification of which commences after regulations are proposed by publication in the Federal Register.

The 1977 amendments to the Act altered or added numerous provisions that apply to the process of establishing standards of performance.

1. EPA is required to list the categories of major stationary sources that have not already been listed and regulated under standards of performance. Regulations must be promulgated for these new categories on the following schedule:

   a. 25 percent of the listed categories by August 7, 1980.
   b. 75 percent of the listed categories by August 7, 1981.
   c. 100 percent of the listed categories by August 7, 1982.

   A governor of a State may apply to the Administrator to add a category not on the list or may apply to the Administrator to have a standard of performance revised.

2. EPA is required to review the standards of performance every four years and, if appropriate, revise them.

3. EPA is authorized to promulgate a standard based on design, equipment, work practice, or operational procedures when a standard based on emission levels is not feasible.

4. The term "standards of performance" is redefined, and a new term "technological system of continuous emission reduction" is defined. The new definitions clarify that the control system must be continuous and may include a low- or non-polluting process or operation.

5. The time between the proposal and promulgation of a standard under Section 111 of the Act may be extended to 6 months.

Standards of performance, by themselves, do not guarantee protection of health or welfare because they are not designed to achieve any specific air quality levels. Rather, they are designed to reflect the degree of emission limitation achievable through application of the best adequately demonstrated technological system of continuous emission reduction, taking into consideration the cost of achieving such emission reduction, any non-air-quality health and environmental impacts, and energy requirements.

Congress had several reasons for including these requirements. First, standards with a degree of uniformity are needed to avoid situations where some States may attract industries by relaxing standards relative to other cost savings by avoiding the need for more expensive retrofitting when pollution ceilings may be reduced in the future. Fourth, certain types of standards for coal-burning sources can adversely affect the coal market by driving up the price of low-sulfur coal or effectively excluding certain coals from the reserve base because their untreated pollution potentials are high. Congress does not intend that new source performance standards contribute to these problems. Fifth, the standard-setting process should create incentives for improved technology.

Promulgation of standards of performance does not prevent State or local agencies from adopting more stringent emission limitations for the same sources. States are free under Section 116 of the Act to establish even more stringent emission limits than those established under Section 111 or those necessary to attain or maintain the National Ambient Air Quality Standards (NAAQS) under Section 110. Thus, new sources may in some cases be subject to limitations more stringent than standards of performance under Section 111, and prospective owners and operators of new sources should be aware of this possibility in planning for such facilities.

A similar situation may arise when a major emitting facility is to be constructed in a geographic area that falls under the prevention of significant deterioration of air quality provisions of Part C of the Act. These provisions require, among other things, that major emitting facilities to be constructed in such areas are to be subject to best available control technology. The term Best Available Control Technology (BACT), as defined in the Act, means

> ". . . an emission limitation based on the maximum degree of reduction of each pollutant subject to regulation under this Act emitted from, or which results from, any major emitting facility, which the permitting authority, on a case-by-case basis, taking into account energy, environmental, and economic impacts and other costs, determines is achievable for such facility through application of production processes and available methods, systems, and techniques, including fuel cleaning or treatment or innovative fuel combustion techniques

> for control of each such pollutant. In no event shall application of "best available control technology" result in emissions of any pollutants which will exceed the emissions allowed by any applicable standard established pursuant to sections 111 or 112 of this Act. (Section 169(3))

Although standards of performance are normally structured in terms of numerical emission limits where feasible, alternative approaches are sometimes necessary. In some cases physical measurement of emissions from a new source may be impractical or exorbitantly expensive. Section 111(h) provides that the Administrator may promulgate a design or equipment standard in those cases where it is not feasible to prescribe or enforce a standard of performance. For example, emissions of hydrocarbons from storage vessels for petroleum liquids are greatest during tank filling. The nature of the emissions, high concentrations for short periods during filling and low concentrations for longer periods during storage, and the configuration of storage tanks make direct emission measurement impractical. Therefore, a more practical approach to standards of performance for storage vessels has been equipment specification.

In addition, Section 111(j) authorizes the Administrator to grant waivers of compliance to permit a source to use innovative continuous emission control technology. In order to grant the waiver, the Administrator must find: (1) a substantial likelihood that the technology will produce greater emission reductions than the standards require or an equivalent reduction at lower economic energy or environmental cost; (2) the proposed system has not been adequately demonstrated; (3) the technology will not cause or contribute to an unreasonable risk to the public health, welfare, or safety; (4) the governor of the State where the source is located consents; and (5) the waiver will not prevent the attainment or maintenance of any ambient standard. A waiver may have conditions attached to assure the source will not prevent attainment of any NAAQS. Any such condition will have the force of a performance standard. Finally, waivers have definite end dates and may be terminated earlier if the conditions are not met or if the system fails to perform as expected. In such a case, the source may be given up to 3 years to to meet the standards with a mandatory progress schedule.

## 2.2 SELECTION OF CATEGORIES OF STATIONARY SOURCES

Section 111 of the Act directs the Adminstrator to list categories of stationary sources. The Administrator ". . . shall include a category of sources in such list if in his judgement it causes, or contributes significantly to, air pollution which may reasonably be anticipated to endanger public health or welfare." Proposal and promulgation of standards of performance are to follow.

Since passage of the Clean Air Amendments of 1970, considerable attention has been given to the development of a system for assigning priorities to various source categories. The approach specifies areas of interest by considering the broad strategy of the Agency for implementing the Clean Air Act. Often, these "areas" are actually pollutants emitted by stationary sources. Source categories that emit these pollutants are evaluated and ranked by a process involving such factors as: (1) the level of emission control (if any) already required by State regulations, (2) estimated levels of control that might be required from standards of performance for the source category, (3) projections of growth and replacement of existing facilities for the source category, and (4) the estimated incremental amount of air pollution that could be prevented in a preselected future year by standards of performance for the source category. Sources for which new source performance standards were promulgated or under development during 1977, or earlier, were selected on these criteria.

The Act amendments of August 1977 establish specific criteria to be used in determining priorities for all major source categories not yet listed by EPA. These are: (1) the quantity of air pollutant emissions that each such category will emit, or will be designed to emit; (2) the extent to which each such pollutant may reasonably be anticipated to endanger public health or welfare; and (3) the mobility and competitive nature of each such category of sources and the consequent need for nationally applicable new source standards of performance.

The Administrator is to promulgate standards for these categories according to the schedule referred to earlier.

In some cases it may not be feasible immediately to develop a standard for a source category with a high priority. This might happen when a program of research is needed to develop control techniques or because techniques for sampling and measuring emissions may require refinement. In the developing of standards, differences in the time required to complete the necessary investigation for different source categories must also be considered. For example, substantially more time may be necessary if numerous pollutants must be investigated from a single source category. Further, even late in the development process the schedule for completion of a standard may change. For example, inablility to obtain emission data from well-controlled sources in time to pursue the development process in a systematic fashion may force a change in scheduling. Nevertheless, priority ranking is, and will continue to be, used to establish the order in which projects are initiated and resources assigned.

After the source category has been chosen, the types of facilities within the source category to which the standard will apply must be determined. A source category may have several facilities that cause air pollution, and emissions from some of these facilities may vary from insignificant to very expensive to control. Economic studies of the source category and of applicable control technology may show that air pollution control is better served by applying standards to the more severe pollution sources. For this reason, and because there is no adequately demonstrated system for controlling emissions from certain facilities, standards often do not apply to all facilities at a source. For the same reasons, the standards may not apply to all air pollutants emitted. Thus, although a source category may be selected to be covered by a standard of performance, not all pollutants or facilities within that source category may be covered by the standards.

## 2.3 PROCEDURE FOR DEVELOPMENT OF STANDARDS OF PERFORMANCE

Standards of performance must (1) realistically reflect best demonstrated control practice; (2) adequately consider the cost, the non-air-quality health and environmental impacts, and the energy requirements of such control; (3) be applicable to existing sources that are modified or reconstructed as well as new installations; and (4) meet these conditions for all variations of operating conditions being considered anywhere in the country.

The objective of a program for developing standards is to identify the best technological system of continuous emission reduction that has been adequately demonstrated. The standard-setting process involves three principal phases of activity: (1) information gathering, (2) analysis of the information, and (3) development of the standard of performance.

During the information-gathering phase, industries are queried through a telephone survey, letters of inquiry, and plant visits by EPA representatives. Information is also gathered from many other sources, and a literature search is conducted. From the knowledge acquired about the industry, EPA selects certain plants at which emission tests are conducted to provide reliable data that characterize the pollutant emissions from well-controlled existing facilities.

In the second phase of a project, the information about the industry and the pollutants emitted is used in analytical studies. Hypothetical "model plants" are defined to provide a common basis for analysis. The model plant definitions, national pollutant emission data, and existing State regulations governing emissions from the source category are then used in establishing "regulatory alternatives." These regulatory alternatives are essentially different levels of emission control.

EPA conducts studies to determine the impact of each regulatory alternative on the economics of the industry and on the national economy, on the environment, and on energy consumption. From several possibly applicable alternatives, EPA selects the single most plausible regulatory alternative as the basis for a standard of performance for the source category under study.

In the third phase of a project, the selected regulatory alternative is translated into a standard of performance, which, in turn, is written in the form of a Federal regulation. The Federal regulation, when applied to newly constructed plants, will limit emissions to the levels indicated in the selected regulatory alternative.

As early as is practical in each standard-setting project, EPA representatives discuss the possibilities of a standard and the form it might take with members of the National Air Pollution Control Techniques Advisory Committee. Industry representatives and other interested parties also participate in these meetings.

The information acquired in the project is summarized in the Background Information Document (BID). The BID, the standard, and a preamble explaining the standard are widely circulated to the industry being considered for control, environmental groups, other government agencies, and offices within EPA. Through this extensive review process, the points of view of expert reviewers are taken into consideration as changes are made to the documentation.

A "proposal package" is assembled and sent through the offices of EPA Assistant Administrators for concurrence before the proposed standard is officially endorsed by the EPA Administrator. After being approved by the EPA Administrator, the preamble and the proposed regulation are published in the Federal Register.

As a part of the Federal Register announcement of the proposed regulation, the public is invited to participate in the standard-setting process. EPA invites written comments on the proposal and also holds a public hearing to discuss the proposed standard with interested parties. All public comments are summarized and incorporated into a second volume of the BID. All information reviewed and generated in studies in support of the standard of performance is available to the public in a "docket" on file in Washington, D. C.

Comments from the public are evaluated, and the standard of performance may be altered in response to the comments.

The significant comments and EPA's position on the issues raised are included in the "preamble" of a "promulgation package," which also contains the draft of the final regulation. The regulation is then subjected to another round of review and refinement until it is approved by the EPA Administrator. After the Administrator signs the regulation, it is published as a "final rule" in the Federal Register.

## 2.4 CONSIDERATION OF COSTS

Section 317 of the Act requires an economic impact assessment with respect to any standard of performance established under Section 111 of the Act. The assessment is required to contain an analysis of (1) the costs of compliance with the regulation, including the extent to which the cost of compliance varies depending on the effective date of the regulation and the development of less expensive or more efficient methods of compliance, (2) the potential inflationary or recessionary effects of the regulation, (3) the effects the regulation might have on small business with respect to competition, (4) the effects of the regulation on consumer costs, and (5) the effects of the regulation on energy use. Section 317 also requires that the economic impact assessment be as extensive as practicable.

The economic impact of a proposed standard upon an industry is usually addressed both in absolute terms and in terms of the control costs that would be incurred as a result of compliance with typical, existing State control regulations. An incremental approach is necessary because both new and existing plants would be required to comply with State regulations in the absence of a Federal standard of performance. This approach requires a detailed analysis of the economic impact from the cost differential that would exist between a proposed standard of performance and the typical State standard.

Air pollutant emissions may cause water pollution problems, and captured potential air pollutants may pose a solid waste disposal problem. The total environmental impact of an emission source must, therefore, be analyzed and the costs determined whenever possible.

A thorough study of the profitability and price-setting mechanisms of the industry is essential to the analysis so that an accurate estimate of potential adverse economic impacts can be made for proposed standards. It is also essential to know the capital requirements for pollution control systems already placed on plants so that the additional capital requirements necessitated by these Federal standards can be placed in proper perspective. Finally, it is necessary to assess the availability of capital to provide the additional control equipment needed to meet the standards of performance.

## 2.5 CONSIDERATION OF ENVIRONMENTAL IMPACTS

Section 102(2)(C) of the National Environmental Policy Act (NEPA) of 1969 requires Federal agencies to prepare detailed environmental impact statements on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment. The objective of NEPA is to build into the decision-making process of Federal agencies a careful consideration of all environmental aspects of proposed actions.

In a number of legal challenges to standards of performance for various industries, the United States Court of Appeals for the District of Columbia Circuit has held that environmental impact statements need not be prepared by the Agency for proposed actions under Section 111 of the Clean Air Act. Essentially, the Court of Appeals has determined that the best system of emission reduction requires the Administrator to take into account counter-productive environmental effects of a proposed standard, as well as economic costs to the industry. On this basis, therefore, the Court established a narrow exemption from NEPA for EPA determination under Section 111.

In addition to these judicial determinations, the Energy Supply and Environmental Coordination Act (ESECA) of 1974 (PL-93-319) specifically exempted proposed actions under the Clean Air Act from NEPA requirements. According to section 7(c)(1), "No action taken under the Clean Air Act shall be deemed a major Federal action significantly affecting the quality of the human environment within the meaning of the National Environmental Policy Act of 1969." (15 U.S.C. 793(c)(1))

Nevertheless, the Agency has concluded that the preparation of environmental impact statements could have beneficial effects on certain regulatory actions. Consequently, although not legally required to do so by section 102(2)(C) of NEPA, EPA has adopted a policy requiring that environmental impact statements be prepared for various regulatory actions, including standards of performance developed under section 111 of the Act. This voluntary preparation of environmental impact statements, however, in no way legally subjects the Agency to NEPA requirements.

To implement this policy, a separate section in this document is devoted solely to an analysis of the potential environmental impacts associated with the proposed standards. Both adverse and beneficial impacts in such areas as air and water pollution, increased solid waste disposal, and increased energy consumption are discussed.

## 2.6 IMPACT ON EXISTING SOURCES

Section 111 of the Act defines a new source as ". . . any stationary source, the construction or modification of which is commenced . . ." after the proposed standards are published. An existing source is redefined as a new source if "modified" or "reconstructed" as defined in amendments to the general provisions of Subpart A of 40 CFR Part 60, which were promulgated in the Federal Register on December 16, 1975 (40 FR 58416).

Promulgation of a standard of performance requires States to establish standards of performance for existing sources in the same industry under Section 111 (d) of the Act if the standard for new sources limits emissions of a designated pollutant (i.e., a pollutant for which air quality criteria have not been issued under Section 108 or which has not been listed as a hazardous pollutant under Section 112). If a State does not act, EPA must establish such standards. General provisions outlining procedures for control of existing sources under Section 111(d) were promulgated on November 17, 1975, as Subpart B of 40 CFR Part 60 (40 FR 53340).

## 2.7 REVISION OF STANDARDS OF PERFORMANCE

Congress was aware that the level of air pollution control achievable by any industry may improve with technological advances. Accordingly, Section 111 of the Act provides that the Administrator ". . . shall, at least every four years, review and, if appropriate, revise . . ." the standards. Revisions are made to assure that the standards continue to reflect the best systems that become available in the future. Such revisions will not be retroactive, but will apply to stationary sources constructed or modified after the proposal of the revised standards.

# 3. THE PRESSURE SENSITIVE TAPE AND LABEL INDUSTRY

The coating of pressure sensitive tapes and labels (PSTL) is a "converting" operation, one in which some backing material (paper, cloth, cellophane, etc.) is coated one or more times to create a tape or label that sticks on contact. The term pressure sensitive indicates that the adhesive bond is formed on contact, without wetting, heating, or adding a curing agent.

The pressure sensitive tape and label industry is a sub-category of paper coating, or the even more general classification of industrial surface coating. It belongs in the Standard Industrial Classification (SIC) 2641.

Pressure sensitive adhesive coatings can be used in the manufacture of a diverse range of products. This includes not only tapes and labels but a variety of decorative and architectural coated products. This study includes all pressure sensitive adhesive coating operations and also release coating operations. All of these operations are referred to as the pressure sensitive tapes and labels (PSTL) industry.

## 3.1 GENERAL INDUSTRY DATA

There is very little information publicly available concerning the pressure sensitive tape and label industry. Product slates, production rates, types of processes, and solvents used are all considered proprietary information by most of the companies.

The information presented in this chapter was developed largely from direct contact with the individual companies. The resulting data represents a summary of the confidential responses of about 58 percent of all companies involved in the manufacture of pressure sensitive tapes and labels. Industry-wide figures are, therefore, an extrapolation from this data base. As such, they should be used roughly to identify trends but not as an exact representation. All the information in this section came from that survey unless specifically referenced to the contrary.

This study has identified 90 firms that are involved in the coating of pressure sensitive tapes and labels to some extent. Most of these are either very small companies, or large companies with only a small percentage of their business devoted to the production of pressure sensitive products.

This industry is relatively concentrated in nature. It has been estimated that more than 80 percent of all pressure sensitive tape production is accounted for by the five largest companies.[1] Similarly, more than 75 percent of all pressure sensitive labels are produced by the top six companies.

The PSTL industry has experienced historical annual growth rates ranging from 7 to 10 percent. This average growth rate reflects two different effects, the growth rate for existing products and for the development of new products. The growth rate for mature existing products is comparatively low and is normally in proportion to the economic growth of industry in general. The development of new products, however, has enjoyed rapid growth. Most new product development in the future will be in the application of pressure sensitive adhesives to miscellaneous architectural and decorative products, rather than in the more mature tapes and labels.

A recent market study predicted growth rates for tapes, labels, and specialty products.[2] The pressure sensitive tape market was estimated to be 900 million dollars in 1978, and its growth was projected to 1.6 billion dollars in 1985. That represents an average annual growth of 8.6 percent. The label market was forecast to grow from 485 million dollars in 1978 to 923 million in 1985, or an average annual growth rate of 9.6 percent. It was further indicated that labels would enjoy more rapid growth until 1981 (about 12 percent per year) and then settle into a more moderate growth pattern (about 8 percent per year) as new markets start to diminish. In contrast, the specialty market for pressure sensitive adhesives is forecast to grow at about 13 percent annually with only a slight decline over the period to 1985.

The production of pressure sensitive tapes and labels is accomplished in over 100 plants distributed geographically in clusters. The largest concentration is in the northeast, representing about 48 percent of the industry (ranked here according to uncontrolled emissions). The next largest concentration is in the midwest (primarily around the Great Lakes) with about 33 percent of the industry. The remaining 19 percent is split evenly between the southeast and the far western states with very few operations in the southwest or Rocky Mountain area. Based on value of shipment data, the north central U.S. represented the greatest production area.

For the purposes of this BID, an affected facility will be defined as a single coating line (which is composed of a coating head, an oven, and a transport system). Each of the pressure sensitive manufacturing plants will have from one to thirty such coating lines, with an overall average of about three lines per plant. This would indicate a total of about 300 coating lines in pressure sensitive service.

The uncontrolled VOC emissions from a single coating line can range from about 10 metric tons per year up to more than 10,000 metric tons per year, with an average of about 1700 metric tons per year. The estimated total national VOC emissions potential from the pressure sensitive tapes and label industry is 600,000 metric tons per year. The detailed basis for this estimate is given in Chapter 7.

Approximately 20 percent of the companies responding employed some form of emission control equipment. This can be further characterized as about 36 percent of the large companies employing emission control and about 16 percent of the medium companies and small-sized companies.

## 3.2 PROCESSES AND THEIR EMISSIONS

There are five basic coating processes which can be used in the coating of pressure sensitive adhesives, those being:

- solvent-based coating,
- waterborne (emulsion) coating,
- hot melt coating,
- calender coating, and
- pre-polymer coating.

More than 85 percent of the existing pressure sensitive materials are produced by solvent-based coating.[3] Because of its broad application, solvent-based coating techniques will be described here in great detail.

Waterborne coating and hot melt coating are two promising alternate technologies. They offer significant advantages over solvent-based coating in environmental, economic, and energy factors. They have not yet, however, been demonstrated to produce equivalent adhesive performance across the full spectrum of pressure sensitive products. Each of these alternative coating methods will be discussed qualitatively and compared to solvent-based coating.

The process of calendering is a 100 percent solids coating process in which the web is impregnated with a granular solid adhesive by extreme pressure. This process is applicable to only a few combinations of coatings and backing materials. It is not expected that the use of calendering could be extended to replace a solvent coating, and it will not be covered further in this document.

Since many of the coating materials are polymeric in nature, it is possible to coat the web with an oligomer (a mixture of the monomer and various polymers) and then cure it to the polymer form. This type of coating technique (sometimes call pre-polymer coating) is still in the experimental stage. The curing can be accomplished by exposing the coating to ultraviolet (UV), infrared (IR), or electron beams (EB). While this process holds considerable promise for the future, much developmental work remains to be done. Pre-polymer coating will not be discussed any further here.

Each of these coating techniques can be used in the application of several different types of coating. Among these are:

- Adhesives - This is universal to all pressure sensitive tapes and labels. The adhesive is usually the heaviest coating on any given product, and as such it uses the most solvent.

- Release agents - Also called "backsize", this coating is applied to the backside of tape or the mounting paper for labels. The function of the release agent is to allow smooth and easy unrolling of the tape, or removal of the label from the mounting paper.

- Primers - A primer or precoat is a material which is coated before the adhesive and improves the bond between the backing material and the adhesive.
- Coloring agents - Various pigments and dyes may be coated onto the backing (or saturate the backing) for decorative purposes.
- Saturants - The backing may be saturated with various materials to modify its properties. For instance, a paper backing may be saturated with synthetic rubber to increase its tensile strength and flexibility.

Adhesive coating is a necessary step in the manufacture of all pressure sensitive adhesives. It is generally the heaviest coating, and therefore results in the highest solvent emissions. Because of this, adhesive coating will be used as the example in most of the following discussions. When the coating of other materials causes a unique situation, it will be noted.

### 3.2.1 Solvent-Based Coating

Solvent-based coating is currently the dominant method for manufacturing pressure sensitive tapes and labels. Years of developmental work have brought solvent-coating techniques a wide range of applications, which include many different kinds of coating materials, at various coating weights, onto many different kinds of backing materials. Solvent-based coating is able to produce superior adhesive products across this wide range of applications.

Solvent-based coating has several drawbacks, however, which may limit its growth in the future. The worst of these drawbacks is the emission problem. Solvent evaporation from the coated product results in two streams of VOC emissions. The largest stream is the concentrated exhaust from the drying ovens. The other is evaporative loss into the work place, or fugitive emissions. While equipment is available to reduce these emissions, it adds to the cost and complexity of the coating operation.

The second drawback of solvent-based coating technology is that it requires more energy than other coating techniques.[4] The concentration of VOC in the oven must be kept very low for safety reasons. Large quantities of dilution air must be circulated through the oven to achieve this low concentration, and large quantities of energy are required to heat this air to oven temperature. In light of rapidly increasing fuel prices, this high energy requirement may be a more serious problem in the future than emission control.

The third problem is economic. The organic solvents used in this coating process are derived from petroleum after a high degree of processing and purification. In its uncontrolled form, solvent-based coating uses about two pounds of solvent per pound of coating material on a once-through basis. Solvent coating without some form of recovery system may soon be economically unattractive with rising petrochemical prices.

The following sections will describe the process of solvent-based coating. Particular emphasis will be placed on the equipment and operating procedures that affect the emissions and energy requirements mentioned above.

3.2.1.1 Process Description for Solvent-Based Coating. Solvent-based coating is a simple process conceptually. The web (a continuous roll of backing material) is unrolled, coated, dried, and rolled up. This process is shown schematically in Figure 3-1. The actual equipment to accomplish this is large and complex. Most of the equipment is involved in the transport and protection of the relatively fragile web. Only the coating head and the oven are of interest in this study, because of their effect on emissions.

The type of coating head used has a great effect on the quality of the coated product, but only a minor effect on emissions. The viscosity of the coating formulation must be tailored to meet the requirements of each particular coating head. Since the viscosity is controlled primarily by the amount of solvent used in the formulation, the coating head can affect emission levels. The fact that the operating viscosity range for each coating head is wide (and often overlaps with others) tends to minimize this effect.

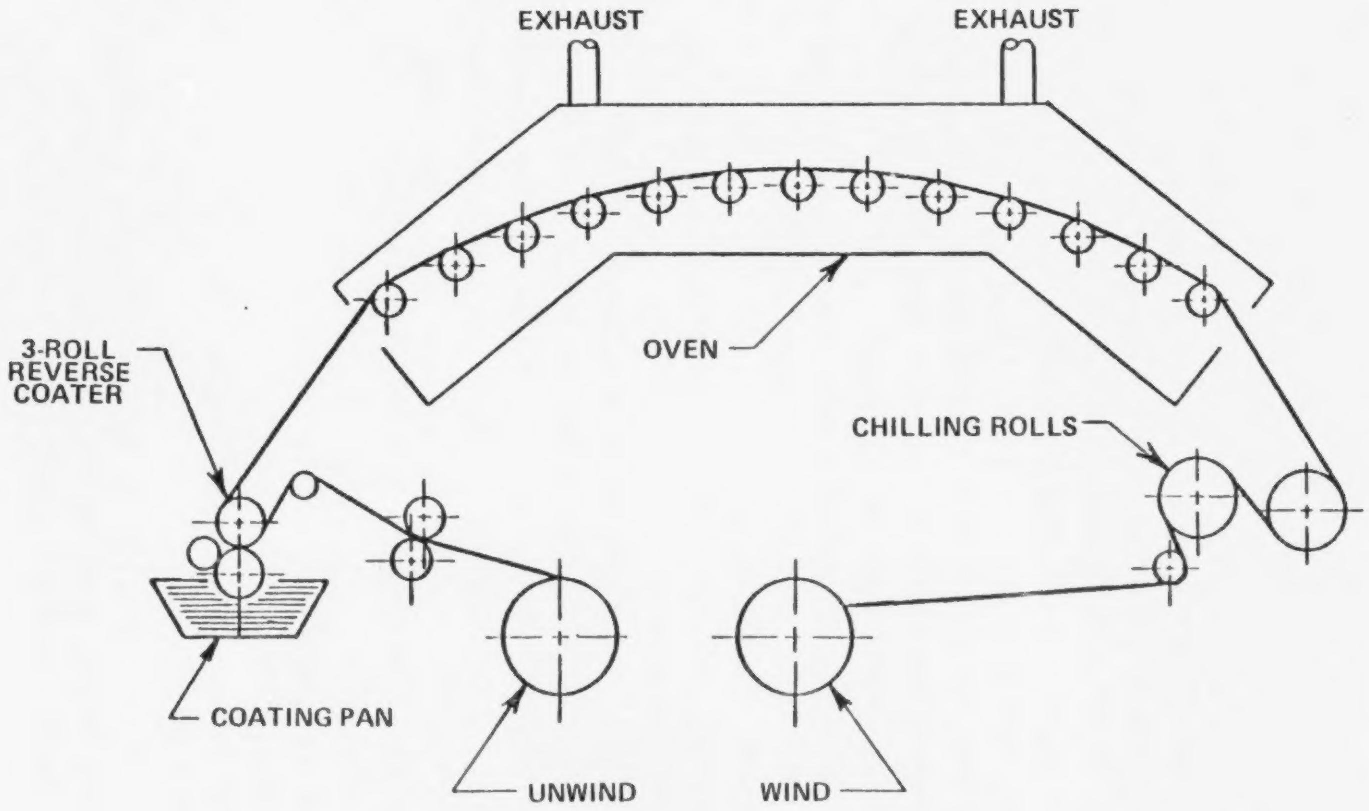

EXHAUST
EXHAUST
3-ROLL REVERSE COATER
OVEN
CHILLING ROLLS
COATING PAN
UNWIND
WIND

Figure 3-1. Schematic diagram of a simple coating line.

The coating head may also affect the level of fugitive emissions. Those coaters which use a pan type feed system expose more area to evaporative loss than those using a nozzle type of feed. Similarly, the more complex coaters with several coating rollers have a much larger exposed area than the simpler designs.

There are many types of coating heads available, but they can be broken down into three basic categories. The first category works by applying excess coating to the web, and then scraping it off to the desired thickness. Examples of this type of coater are the knife coater, blade coater, metering rod coater, and the air knife coater. Diagrams of several of these coating heads are shown in Figure 3-2.

The second category of coater meters on a predetermined amount of coating. The two most common types of coaters in this category are the reverse roll and the gravure, shown in Figure 3-3.

The third category does not actually apply a surface coating, but rather saturates the backing. The dip and squeeze coater shown in Figure 3-4 is the most common example.

The second piece of major equipment on a coating line is the oven, the major functions of which are:

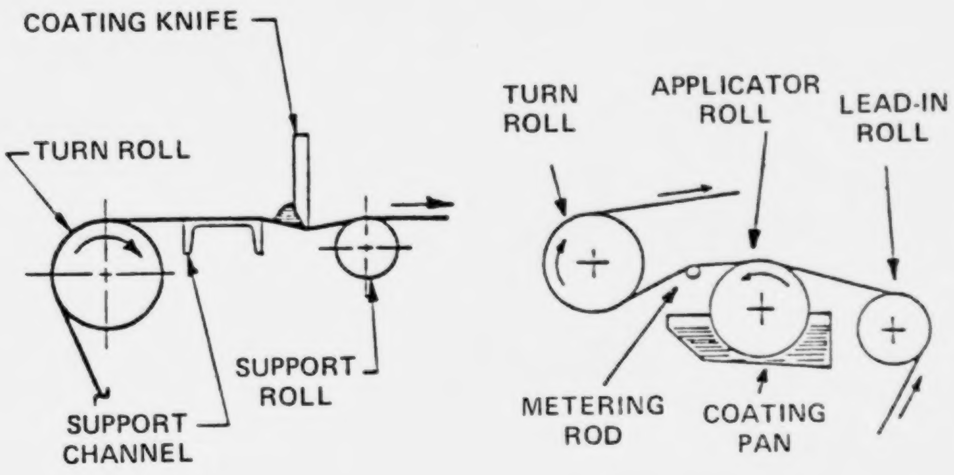
- drying the coating by evaporating the solvent, and/or
- finishing the curing of the polymer coating.

The exhaust from the ovens is by far the largest source of potential VOC emissions. The oven configuration and operation can have a significant effect on the efficiency of any downstream emission control equipment.

The important properties of a drying/curing oven include:

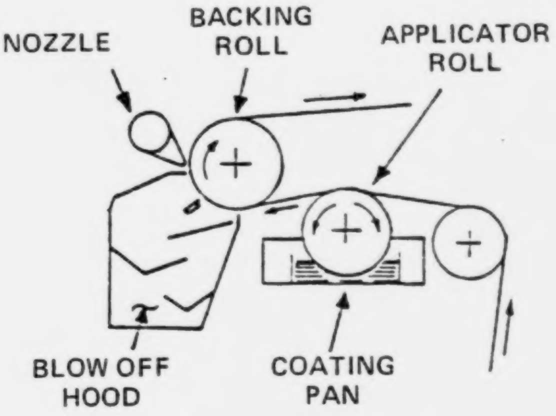
- the source of heat,
- the temperature profile,
- the residence time,
- the allowable hydrocarbon concentration, and
- the oven circulation.

There are two basic types of heating used in drying ovens, direct and indirect. Direct heating routes the hot products of combustion (blended off with ambient air to the proper temperature) directly into


COATING KNIFE
TURN ROLL
SUPPORT ROLL
SUPPORT CHANNEL
TURN ROLL
APPLICATOR ROLL
LEAD-IN ROLL
METERING ROD
COATING PAN

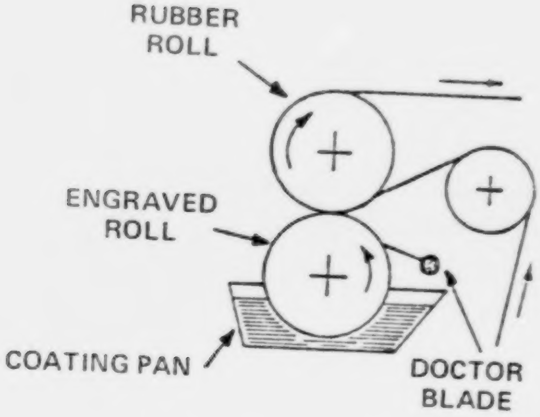
FLOATING KNIFE COATER

METERING ROD COATER

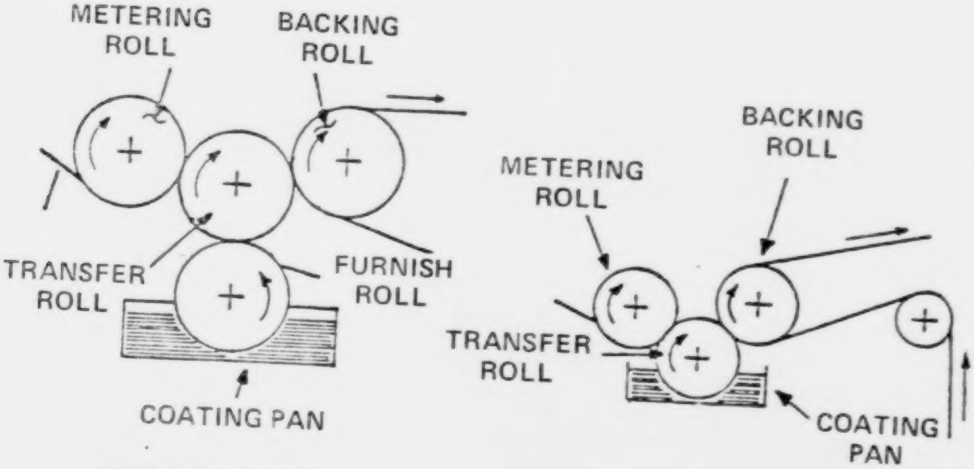

NOZZLE
BACKING ROLL
APPLICATOR ROLL
BLOW OFF HOOD
COATING PAN

AIR KNIFE COATER

Figure 3-2. Coating head configurations.


RUBBER ROLL
ENGRAVED ROLL
COATING PAN
DOCTOR BLADE

GRAVURE COATER


METERING ROLL
BACKING ROLL
TRANSFER ROLL
FURNISH ROLL
COATING PAN
BACKING ROLL
METERING ROLL
TRANSFER ROLL
COATING PAN

REVERSE ROLL COATER-FOUR ROLL TYPE

REVERSE ROLL COATER (3 ROLL PAN FED)

Figure 3-3. Metering type coating heads.

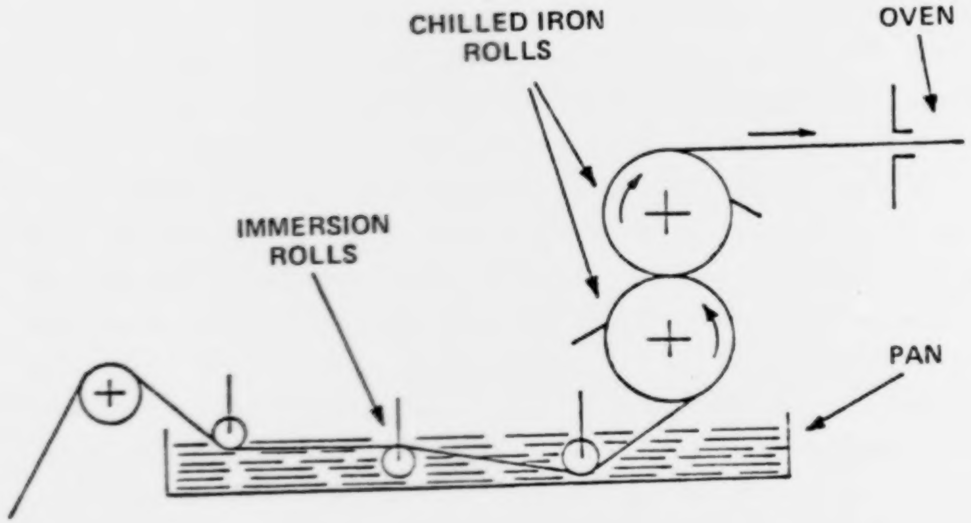

CHILLED IRON ROLLS
OVEN
IMMERSION ROLLS
PAN

Figure 3-4. Dip and squeeze coater.

the drying zone. The fuels for a direct fired oven are usually limited to natural gas or liquefied petroleum gas (usually propane), because of the requirements for clean burning. Fuel oil, or other heavier fuels, could potentially produce enough soot and other particulates to adversely affect the coating.

In an indirect heated oven, the incoming air stream exchanges heat with steam or combustion products, but does not physically mix with them. This heat transfer may be accomplished in several types of heat exchangers, such as shell-and-tube or plate type.

Direct fired ovens are more common because of their higher thermal efficiency. Indirect heated ovens lose efficiency both in the production of steam and in the heat transfer from steam to oven air. As a result, indirect heating is usually employed only for very small ovens, for cases where product contamination cannot be tolerated, and for cases where surplus steam is already available. Indirect heating may also be used in the secondary recovery of heat from the incineration of solvent in the oven exhaust.

The average oven temperature is important to both the process and any add-on control equipment. For drying purposes, the oven must be at a temperature above the boiling point of the solvent. If any curing is to be done, even higher temperatures are required. The resulting average temperature affects the amount of cooling needed before carbon adsorption or preheating before incineration.

In addition to the bulk average temperature, the temperature profile is very important to product quality. If the initial drying proceeds too fast, coating flaws called "craters" or "fish-eyes" can develop. Yet if the drying step is done slowly at low temperatures, much longer ovens would be necessary to completely dry the coating.

The solution to this trade-off is the multizoned oven, illustrated in Figure 3-5. The oven is physically divided into several sections, each with its own hot air supply and exhaust. By holding the temperature of the first zone low, and then gradually increasing in subsequent zones, uniform drying can be carried to completion in a reasonably sized

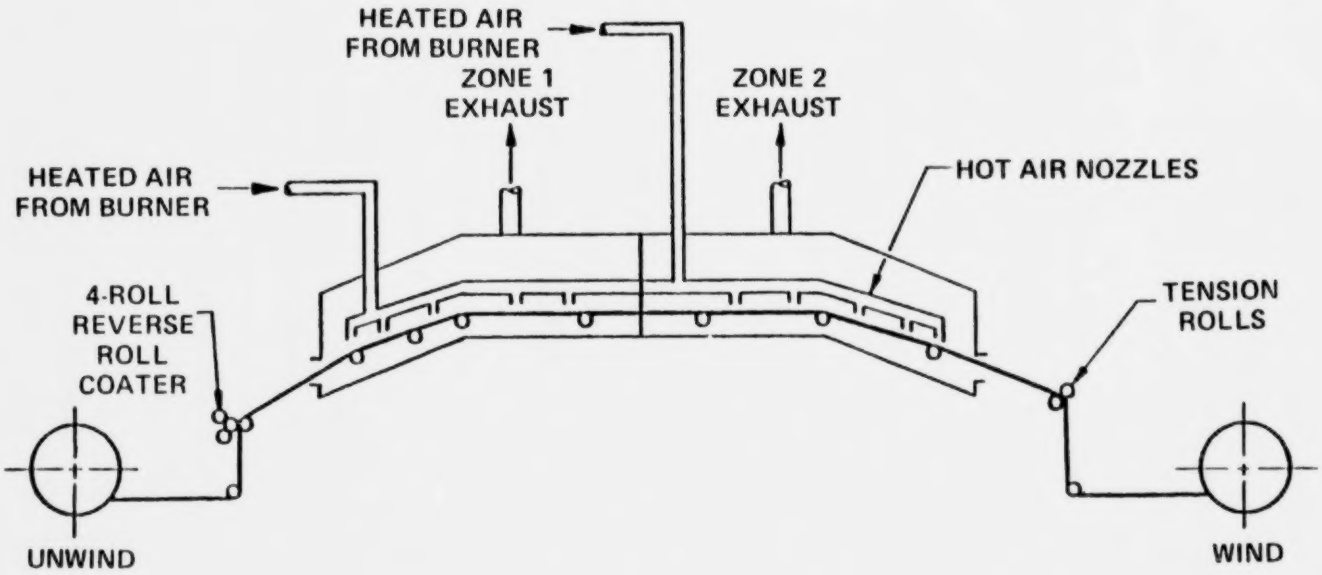

HEATED AIR FROM BURNER
ZONE 1 EXHAUST
ZONE 2 EXHAUST
HEATED AIR FROM BURNER
HOT AIR NOZZLES
4-ROLL REVERSE ROLL COATER
TENSION ROLLS
UNWIND
WIND

Figure 3-5. Two zone drying oven.

oven. This system is also compatible with high temperature curing in later zones. Figure 3-5 illustrates a two zone drying oven. A modern large drying/curing oven may have as many as six zones ranging in temperature from 43°C (110°F) to 204°C (400°F).

The multi-zoned oven adds another degree of complexity to the emission control system. Most of the solvent is evaporated in the early zones. Thus there is the potential to reduce the size of the emission control equipment by excluding one or more of the later oven zone exhausts. This is done at the expense of a decrease in overall control efficiency.

The residence time in the oven is determined by the oven length and the line speed. Residence time is important in determining the amount of solvent that remains in the coating. Residual solvent in the coating from one step may be released during the unrolling phase or subsequent coating steps or during the slitting phase. It has been estimated that from one to five percent of the total solvent used in the coating formulation remains in the product.[5,6,7]

The oven circulation is basically set by the allowable VOC concentration. This concentration is usually expressed as a percent of the Lower Explosive Limit (LEL). For the solvents typically used in coating pressure sensitive tapes and labels, the LEL ranges from 0.8 to 3.0 volume percent of the organic in the air.[8] Older coating lines are usually controlled to 25 percent LEL, while the newer lines have increased this to 40 to 50 percent LEL. The use of continuous LEL monitors on the ovens (to sound alarms and/or shut down the line if necessary) has enabled this advance. The higher the allowable LEL in the oven exhaust, the less dilution air is required for any given solvent loading. This not only reduces the energy requirements of the oven, it also reduces the cost of any downstream emission control equipment.

Coating operators have mentioned special problems with low oven LEL on precoat and silicone release coating lines.[9] With these high-solvent, low-coating-weight applications, oven turndown is especially difficult. Also, most ovens are operated at negative pressures to meet OSHA requirements. The negative pressure causes air infiltration and more dilution of the oven off gas. The problem is particularly pronounced in tandem or multiple coating operations which coat a wide variation of adhesive coating weights. Low coating weights, air infiltration and poor oven turndown can all combine in multiple coating units to reduce the oven LEL.

Figure 3-6 illustrates a tandem coating line. Each pressure sensitive product typically undergoes a minimum of two coating operations. These may be done separately on discrete coating lines, or a single tandem coating line may be used. A tandem coating line is one in which the web undergoes a sequence of coating and drying steps without rewinding between steps. Since this reduces the flexibility of the system, tandem coating lines are best used for large volume products with relatively long run times.

For this study a facility has been defined as a single coating line, which effectively means a coating head and the associated drying/curing oven. By this definition, a tandem coating line would be considered as two (or more) independent facilities. This is the preferred treatment since the subsequent coatings applied in a tandem coating operation often involve radically different solvents and would likely require different types of emission control equipment.

3.2.1.2 Emission Points from Solvent-Based Coating. The only pollutants emitted in significant quantities from solvent-based coating of pressure sensitive tapes and labels are the volatile organic compounds resulting from solvent evaporation. Most of these emissions (80 to 95 percent) are contained in the drying oven exhaust. Some solvent (1 to 5 percent) remains in the coated product. The remainder is lost from a variety of small sources referred to collectively as fugitive emissions.

In an uncontrolled facility, almost all of the solvent used in the coating formulation is emitted to the atmosphere. Most coating formulations range from 5 to 60 weight percent non-volatile solids in the coating formulation, and the remainder is solvent. Using a typical adhesive formulation containing 35 percent percent solids, solvent

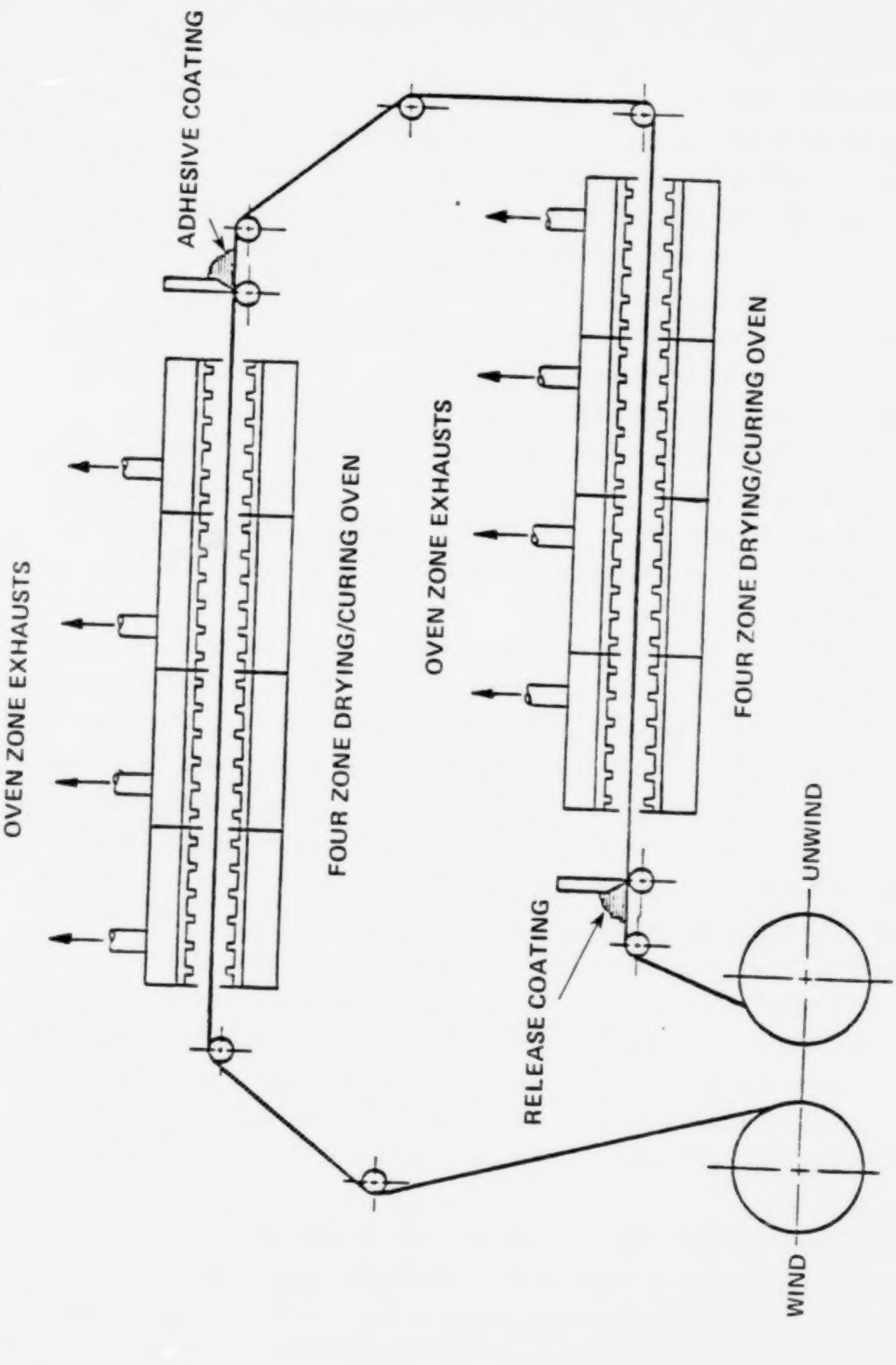

OVEN ZONE EXHAUSTS
FOUR ZONE DRYING/CURING OVEN
ADHESIVE COATING
OVEN ZONE EXHAUSTS
FOUR ZONE DRYING/CURING OVEN
RELEASE COATING
UNWIND
WIND

Figure 3-6. Tandem coating line with four zone ovens.

emissions will be 1.86 kg per kg of coating material. This can further be related to production by a typical coating weight of 0.051 kg/m$^2$ (0.094 lb/sq yd).[10] Solvent emissions would then be about 0.094 kg/m$^2$ (0.173 lb/sq yd).

Most of these solvent emissions appear in the oven exhaust. This stream is relatively concentrated, ranging from 2000 to 5000 ppmv. Flow rates range from 0.5 Nm$^3$/sec (1000 SCFM) to 50 Nm$^3$ (100,000 SCFM). The combined oven temperature ranges from 65°C (150°F) to 121°C (250°F).

Fugitive emissions may occur at any point in the solvent handling process, such as:

- from solvent storage tanks,
- from coating formulation mixing tanks,
- from miscellaneous spills,
- from equipment cleaning,
- from oven leaks, and
- from the coating operation itself.

Fugitive emissions from formulation, storage, and cleanup operations are not included in this regulation because: (1) the storage of hydrocarbons are covered by a separate NSPS, (2) formulation emissions are already controlled to low levels due to safety reasons, and (3) the solvent cleanup emissions are generally low concentration, low volume sources which are very difficult to capture and control. Since the primary emphasis of this study is on the coating operation, losses there will be stressed.

Fugitive emissions during coating come from the unintentional evaporative loss of solvent around the coating head and on the exposed web from the coater to the oven entrance. The magnitude of these losses is determined by the size of the equipment, the line speed, the volatility of the solvent, the temperature, and the air turbulence in the coating area.

Since the first two factors also determine production rate, an interesting relationship develops. Fugitive emissions increase with increasing web width, but decrease with increasing line speed. Since most production gains are achieved by increasing both web width and line speed, this results in a small change in the absolute magnitude of the fugitive emissions. But since oven emissions increase significantly with increasing production, fugitive emissions decrease when expressed as a percent of the total emissions. Thus a small coater might have emissions that are 20 percent fugitive and 80 percent oven, while a large unit would be 5 percent fugitive and 95 percent oven.[5]

Fugitive emissions may be collected for treatment by a system of hoods and/or floor sweeps. The efficiency of this type of collection system is highly dependent on system designs. Some designs call for total enclosures resulting in a theoretical 100 percent fugitive emission capture. The captured gases from the hoods or enclosures can be used as makeup air for the drying ovens. The cost of the fugitive capture system is expected to be a small fraction of the total coating line and VOC control system installed capital cost.

The other possible pollutants from a pressure sensitive tape or label coating facility are particulates, $SO_2$, $NO_x$, and CO from direct-fired drying ovens. The other major type of drying oven, indirect-heated, does not have any combustion pollutants from the oven. Indirect-heated ovens usually use steam-tube heat exchangers. The steam is supplied by an industrial size boiler. The industrial boiler is being examined in a separate NSPS study. A third type of drying oven uses electrical heaters and therefore has no potential emissions.

As previously mentioned, the major fuel used in a direct-fired oven is either natural gas or liquified petroleum gas. Alternate fuels such as fuel oils or coal can not be used because soot or ash from their combustion can adversely affect the product quality. The burning of natural gas or LPG is a very clean process with respect to the formation of particulates, $SO_2$, $NO_x$, and CO. Table 3-1 gives an example of a typical large solvent-based coating facility. The particulate, $SO_2$, $NO_x$, and CO emission rates are calculated from AP-42 emission factors for small industrial boilers or process heaters. Because the emission rates are so small, these pollutants will not be examined any further in this study.

TABLE 3-1. EMISSIONS FROM A TYPICAL LARGE, DIRECT-FIRED COATING LINE USING A SOLVENT-BASED COATING

| | |
|---|---|
| Line size | 1.5 meters (60 inches) |
| Line speed | 1.2 meter/sec (230 fpm) |
| Coating | Solvent-based adhesive (65 wt % solvent, 35 wt% solids) |
| Solvent | Toluene |
| Coating weight | 0.051 kg/m$^2$ (0.094 lb/yd$^2$) |
| Oven heat load | 27,400 k cal/sec (6.5 X 10$^6$ Btu/hr) |
| Amount of solvent controlled | 0.166 kg/sec (22.0 lb/min) |
| Estimated emissions if natural gas is used: | |
| Particulates | 1.2 X 10$^{-5}$ kg/sec (0.002 lb/min) |
| $SO_2$ | 4.9 X 10$^{-7}$ kg/sec (6.5 X 10$^{-5}$ lb/min) |
| $NO_x$ | 0.0065 kg/sec (0.87 lb/min) |
| CO | 0.0011 kg/sec (0.14 lb/min) |
| Estimated emissions if LPG is used: | |
| Particulates | 1.2 X 10$^{-5}$ kg/sec (0.002 lb/min) |
| $SO_2$* | 1.2 X 10$^{-7}$ kg/sec (1.6 X 10$^{-5}$ lb/min) |
| $NO_x$ | 1.0 X 10$^{-4}$ kg/sec (0.013 lb/min) |
| CO | 1.1 X 10$^{-5}$ kg/sec (0.0018 lb/min) |

*Sulfur content in LPG is 0.0009 kg/10$^3$ liter (0.007 lbs/10$^3$ gallon)

3.2.1.3 Existing Regulations and Emissions. Twenty states, the District of Columbia, and Puerto Rico have some form of point source regulation to limit the emissions of VOC. Most of the rest of the states have an ambient air quality standard, but no point source emission limits. A summary of these regulations is presented as Table 3-2.

The VOC emission limits fall into several patterns. The strictest form calls for a maximum of 6.8 kilograms per day (15 pounds per day) or 1.4 kilograms per hour (3 pounds per hour) for "oven emissions". These oven emissions are defined as any organic material which has come in contact with a flame or has been heat cured, heat polymerized, or baked. If these ceiling values cannot be met (and they are so low that no solvent-based coating facility could meet them uncontrolled), then control equipment must be provided to reduce emissions by at least 85 percent. The 85 percent applies only to the captured emissions and is not an overall VOC reduction.

Uncontrolled emissions from pressure sensitive tape and label coating are estimated to be 600,000 metric tons per year. If the above regulations were uniformly applied, the resulting controlled emissions would be approximately 90,000 metric tons per year.

The oldest and probably most well known VOC reduction regulation is California's Rule 66 (now known as Rule 442). Rule 66 was developed by the County of Los Angeles Air Pollution Control District (now the South Basin APCD) in 1966. The rule was later amended in November of 1972.

The two purposes of the regulation were: (1) to reduce total VOC emissions and (2) eliminate organics that were recognized as photochemically reactive. The rule defined an organic solvent as photochemically reactive if the solvent contained greater than 20 percent of its total volume or exceeded any of the volume levels of the solvents listed below:

- no more than 5 percent by volume of compounds with olefinic or cyclo-olefinic unsaturation,
- no more than 8 percent aromatic compounds of 8 or more carbon atoms (with the exception of ethylbenzene),
- no more than 20 percent ethylbenzene, toluene, trichloroethylene, or ketones having branched hydrocarbon structures.

TABLE 3-2. EXISTING STATE REGULATIONS ON EMISSIONS OF VOLATILE ORGANIC COMPOUNDS APPLICABLE TO PRESSURE SENSITIVE COATING

| State | Emission limits | | | | | Notes | Existing pressure sensitive coating? |
|---|---|---|---|---|---|---|---|
| | kg/day | (lb/day) | kg/hr | (lb/hr) | % Reduction | | |
| Alabama | 6.8 | 15 | 1.4 | 3 | 85 | a | ✓ |
| Alaska | --- | -- | --- | - | -- | b | |
| Arizona | 6.8 | 15 | --- | - | -- | a, c | |
| Arkansas | --- | -- | --- | - | -- | b | |
| California | 6.8 | 15 | 1.4 | 3 | 85 | a, d, e, n | ✓ |
| Colorado | 6.8 | 15 | 1.4 | 3 | 85 | a | |
| Connecticut | 6.8 | 15 | 1.4 | 3 | 85 | a | ✓ |
| Delaware | --- | -- | --- | - | -- | b | |
| Florida | --- | -- | --- | - | -- | b | |
| Georgia | --- | -- | --- | - | -- | b | ✓ |
| Hawaii | --- | -- | --- | - | -- | b | |
| Idaho | --- | -- | --- | - | -- | b | |
| Illnois | --- | -- | 3.6 | 8 | 85 | e | ✓ |
| Indiana | 6.8 | 15 | 1.4 | 3 | 85 | e | ✓ |
| Iowa | --- | -- | --- | - | -- | b | ✓ |
| Kansas | --- | -- | --- | - | -- | b | |
| Kentucky | 6.8 | 15 | 1.4 | 3 | 85 | a | ✓ |
| Louisiana | 6.8 | 15 | 1.4 | 3 | 85 | f | |
| Maine | --- | -- | --- | - | -- | b | |
| Maryland | 6.8 | 15 | 1.4 | 3 | 85 | a, g | |
| Massachusetts | 6.8 | 15 | 1.4 | 3 | 85 | a | ✓ |
| Michigan | --- | -- | --- | - | -- | b | ✓ |
| Minnesota | --- | -- | --- | - | -- | b | ✓ |
| Mississippi | --- | -- | --- | - | -- | b | |
| Missouri | --- | -- | --- | - | -- | b | ✓ |
| Montana | --- | -- | --- | - | -- | b | |

TABLE 3-2 (CONTINUED). EXISTING STATE REGULATIONS ON EMISSIONS OF VOLATILE ORGANIC COMPOUNDS APPLICABLE TO PRESSURE SENSITIVE COATING

| State | Emission limits | | | | | Notes | Existing pressure sensitive coating? |
|---|---|---|---|---|---|---|---|
| | kg/day | (lb/day) | kg/hr | (lb/hr) | % Reduction | | |
| Nebraska | --- | -- | --- | - | -- | b | |
| Nevada | --- | -- | --- | - | -- | b | |
| New Hampshire | --- | -- | --- | - | -- | b | |
| New Jersey | --- | -- | --- | - | -- | b | ✓ |
| New Mexico | --- | -- | --- | - | -- | b | ✓ |
| New York | 6.8 | 15 | 1.4 | 3 | 85 | a, h | ✓ |
| North Carolina | 18.1 | 40 | --- | - | 85 | e | ✓ |
| North Dakota | --- | -- | --- | - | -- | b | |
| Ohio | 6.8 | 15 | 1.4 | 3 | 85 | a, i | ✓ |
| Oklahoma . | 6.8 | 15 | 1.4 | 3 | 85 | a | |
| Oregon | --- | -- | --- | - | -- | b | |
| Pennsylvania | 18.1 | 40 | --- | - | 85 | j, k | ✓ |
| Rhode Island | 18.1 | 40 | --- | - | 85 | j, l | |
| South Carolina | --- | -- | --- | - | -- | b | ✓ |
| South Dakota | --- | -- | --- | - | -- | b | ✓ |
| Tennessee | --- | -- | --- | - | -- | b | |
| Texas | 6.8 | 15 | 1.4 | 3 | 85 | e, m | ✓ |
| Utah | --- | -- | --- | - | -- | b | |
| Vermont | --- | -- | --- | - | -- | No regulation | ✓ |
| Virginia | 6.8 | 15 | --- | - | 85 | a, n | |
| Washington | --- | -- | --- | - | -- | b | |
| West Virginia | --- | -- | --- | - | -- | b | |
| Wisconsin | 6.8 | 15 | 1.4 | 3 | 85 | e | ✓ |
| Wyoming | --- | -- | --- | - | -- | b | |
| District of Columbia | 6.8 | 15 | 1.4 | 3 | 85 | a, e | |
| Puerto Rico | 6.8 | 15 | 1.4 | 3 | -- | j, o | |

Notes for Table 3-2.

a) Applies to oven emissions (organic compounds which have been exposed to a flame, or have been heat cured, heat polymerized, or baked).

b) Ambient air standard only.

c) Maricopa County only. Rest of the state calls for "no unreasonable escape of solvents and use of control equipment where needed."

d) Applies to County of Los Angeles and San Francisco Bay Area APCD. County by county regulations, most following this pattern.

e) Applies to photochemically reactive solvents, as defined in Rule 66.

f) Shall reduce where feasible by control methods.

g) Metropolitan Baltimore and surrounding counties. Rest of state limits new sources to a maximum of 250 kg/day (550 lb/day).

h) Applies to New York City Metropolitan area only.

i) Applies to existing sources in Priority I areas and all new sources.

j) Total emissions.

k) City of Philadelphia only.

l) Applies to single machine. Limit of 45 kg/day (100 lb/day) for all operations.

m) For nonphotochemically reactive, 1361 kg/day (3000 lb/day) or 204 kg/hr (450 lb/hr).

n) Applies to AQCR 7 only.

o) Unless equipped with acceptable control.

The rule also provided less stringent VOC emission levels for non-photochemically reactive solvents.[11]

Several states adopted the Rule 66 format. If this type of emissio regulation were universally applicable, current emissions would be in the range of 300,000 to 500,000 metric tons per year. This range is wide because of the uncertainty as to whether manufacturers currently using a reactive solvent (where control equipment is required) would switch to an exempt solvent if the local regulation allowed it.

The Rule 66 regulation is currently being phased out by the State Implementation Plan (SIP) regulations. SIP regulations are required by all states that have non-attainment areas for hydrocarbons. These generally include all the major pressure sensitive industrial areas such as the urban Northeast, Chicago, and Los Angeles. The U.S. Environmental Protection Agency has recommended an emission limit specifically for paper and fabric coating operations.[12] This limit is stated as the following:

| Affected Facility | Recommended Limitation | |
|---|---|---|
| | kg VOC per liter of coating (minus water) | lbs VOC per gallon of coating (minus water) |
| Coating Line | 0.35 | 2.9 |

This regulation requires about the same level of VOC reduction as Rule 66, however, it excludes the preferential treatment of non-photochemically reactive solvents. The recommended CTG limitation is used as the baseline of comparisons in this study.

So far all of the states which are developing SIP regulations, except California, are following the recommended EPA guidelines. California performed an independent study on coating facilities within their state and in August 1978 came up with a separate VOC reduction rule.[13] The proposed rule is stated as the following:

1. After 2 years from date of adoption a person shall not discharge into the atmosphere more than 120 grams of volatile organic compounds per liter of coating (1.0 pound per gallon of coating) as applied, excluding water, from any paper and/or fabric coating application process involving the use of heating ovens.

2. The provisions of Section 1 of this rule shall not apply to·

a. any coating application process which emits less than 6.5 kilograms of volatile organic compounds per day;

b. the use of low-solvent paper or fabric coatings which emit or may emit less than 265 grams of volatile organic compounds per liter of coating as applied, excluding water.

3. Containers for organic solvents and mixing tanks for coatings containing organic solvents shall be free from leaks and shall be covered except when adding or removing materials, cleaning, or when the container is empty.

The California rule applies to all solvent-based coating operations in the state. The South Basin APCD has already adopted this regulation as the law.

### 3.2.2 Waterborne Adhesive and Silicone Release Coatings

Environmental pressure has spurred the search for a coating process that is intrinsically nonpolluting (as opposed to add-on emission control equipment). Waterborne coating is a good example of such a process which is receiving a great deal of attention from coating suppliers, equipment manufacturers, and the producers of pressure sensitive tapes and labels. Already waterborne coating (or emulsion coating) is being used in applications which were the exclusive domain of solvent coating as little as five years ago. Our survey found that 15 percent of the respondents were using waterborne coating to some degree.

Since water replaces the organic solvent as the coating diluent, there are essentially no volatile organic emissions. This also results in a decreased hazard of fire and explosion. VOC concentrations in the work environment are likewise reduced.

Waterborne coating requires less energy in the drying oven. This is due primarily to a great reduction of the dilution air made possible by the lack of explosion hazard.

The equipment for waterborne coating is very similar to that for solvent-based coating. For some release coatings, this similarity will help facilitate the substitution of emulsion coatings for solvent-based. This added familiarity helps promote operator acceptance.

While the acrylic latex adhesives used in waterborne coating are more expensive than rubber-based solvent adhesives, this cost is offset by savings on solvent cost and drying energy. When compared to solvent-based coating with add-on emission control equipment, waterborne coating becomes quite economically attractive.

Waterborne coating technology is applicable to a wide range of coating materials. It has been used successfully to coat both adhesives and release agents. The range of adhesives available for waterborne coating is wider than hot melt, but not as wide as for solvent-based.[14]

The limiting factor on waterborne coating is product development. Waterborne adhesive formulations have been developed that match solvent-based adhesive performance for certain products, but much more work must be done to extend the range of products. Solvent-based coating may never be replaced for use in some specialty products (particularly true with regard to silicone releases), but waterborne coating shows promise as a substitute for much of the field.

3.2.2.1 Process Description for Waterborne Coating. The equipment and procedures used in waterborne coating are very similar to those described for solvent-based coating. The following paragraphs will highlight the areas where differences occur.

The hydraulic properties of the aqueous emulsion are quite different from solvent systems. The viscosity in a solvent formulation is determined by the type of coating material, the type of solvent, and the percent solids. For most coating materials, a limit of 35 to 40 weight percent solids is common. The viscosity of an emulsion is more dependent on the physical properties of the system (degree of mixing and particle size) than on the properties of the coating material. Thus higher molecular weight polymers may be used in coating formulations as high as 60 percent solids.

Most coating heads used for solvent-based coating can be used for aqueous coating. Some of those particularly well suited to aqueous coating are knife, blade, bar, rod, air knife, and gravure coaters. For pan fed coaters, the pan should be recirculated to maintain even mixing.

The oven operation is also slightly different for waterborne coating. Oven temperatures are generally higher because water has a higher boiling point than most organic solvents. The heat of vaporation of water is also higher than that of organic solvents. These two facts give rise to a common misconception that more energy is required to dry an aqueous coating. This neglects the effect of reduced oven dilution air (required to keep solvent level below some specified percent LEL). Up to 90 percent of the heat used in a conventional solvent drying oven is required to heat the dilution air to the oven temperature. Oven energy requirements with an aqueous system range from 10 to 30 percent of those for a comparable solvent system.[15]

To maintain good contacting and turbulence inside the oven at low dilution air rates, exhaust gas recirculation is often employed. This feature is illustrated in Figure 3-7. This principle is equally applicable to solvent-based drying systems.

There are several operating problems unique to waterborne coating. One of these is a structural deformation of the web when using water sensitive substrates.[16] These deformations primarily take the form of curl and cockle. There are many possible solutions, including pretreatment of the web, use of a different backing material, changes in coating and drying procedures, and the addition of small amounts of organic solvent to the formulation. The addition of organics to the formulation should be a short term solution, while other techniques are being developed. This is typically limited to less than ten percent organic solvent, so the resulting emissions are still comparable to the best controlled solvent-based facility.

Waterborne systems may also exhibit foaming problems. These problems can be minimized by careful operating procedures and by the addition of anti-foaming or defoaming agents or both.[17]

It has also been suggested that corrosion may prove to be a long term problem with waterborne systems. This would be particularly important in the retrofit of existing solvent lines to emulsion coating. New designs can specify metallurgy to minimize corrosion.

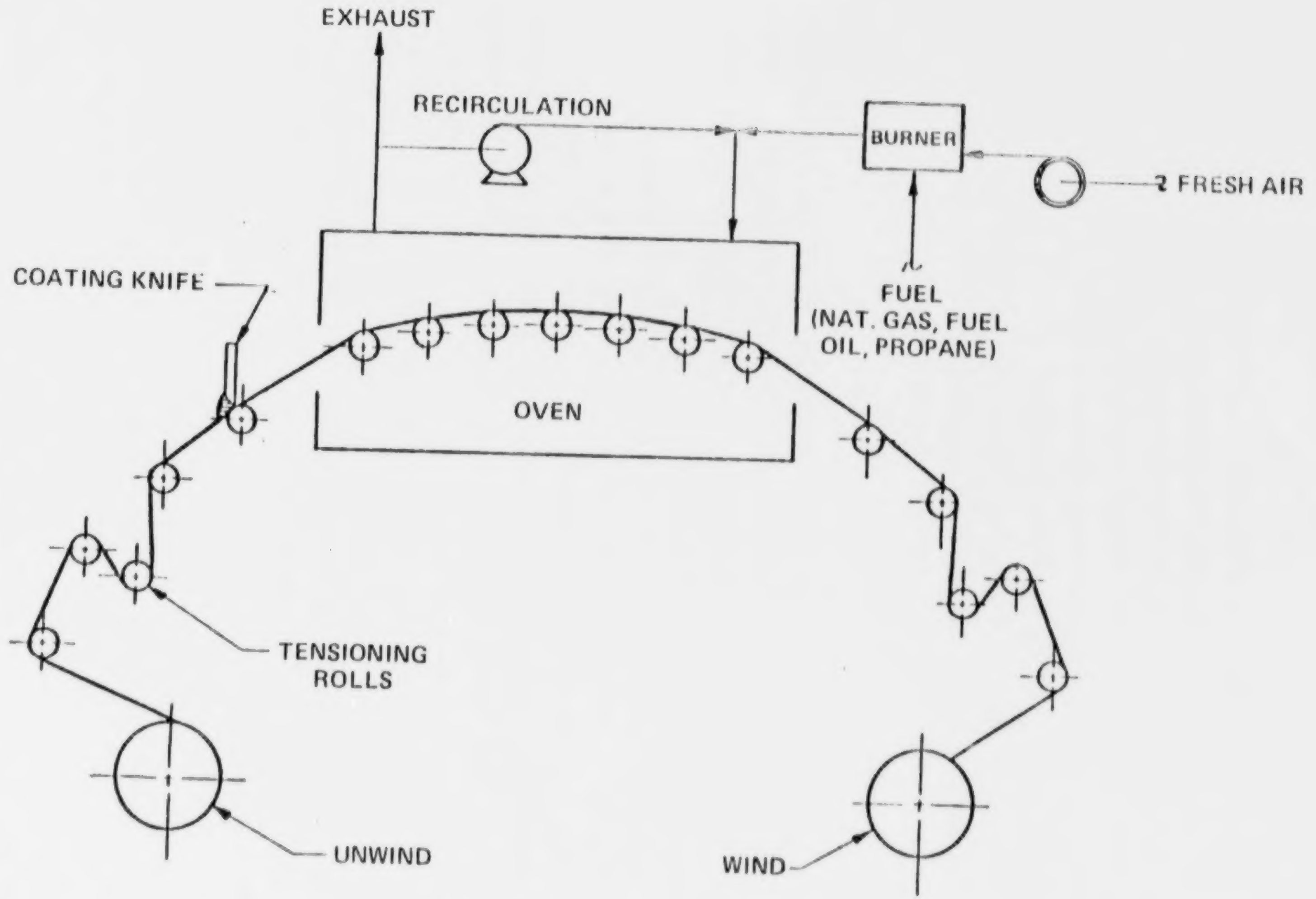

EXHAUST
RECIRCULATION
BURNER
FRESH AIR
COATING KNIFE
FUEL
(NAT. GAS, FUEL
OIL, PROPANE)
OVEN
TENSIONING
ROLLS
UNWIND
WIND

Figure 3-7. Coating line with exhaust recirculation.

3.2.2.2 Sources of Emission. There are typically no significant atmospheric emissions from a waterborne coating facility. If small amounts of organic solvent are added to counteract operating problems, the emission points will be the oven exhaust and fugitives. Since the use of volatile organics in aqueous formulations is typically very low (less than 10 percent), the resulting emissions will be comparable (or better than) the best controlled solvent-based facility.

3.2.2.3 Existing Regulations and Emissions. The same basic VOC emission limits that apply to solvent coating also apply to aqueous coating. Eleven states give a specific exemption to waterborne coating as long as the volatile organics are less than 20 percent of the total volatile material in the formulation.

Emissions from waterborne coating of pressure sensitive tapes and labels may be considered to be an insignificant contributor to the overall industry emissions.

### 3.2.3 Hot Melt Adhesive Coating

Hot melt (or hot applied) pressure sensitive adhesives have been the subject of a great deal of development work during the last ten years. The motivating forces to develop hot melt systems in place of solvent-based systems are similar to those for waterborne coating:

- environmental pressure,
- worker health and safety,
- energy shortage, and
- raw material cost and availability.

Where it can successfully meet product specifications, hot melt coating is an excellent solution to these problems. It is an intrinsically non-polluting process, both in terms of the exterior environment and the work place. Fire and explosion dangers are also minimized by the absence of any volatile hydrocarbons. It has lower energy consumption than either solvent-based or waterborne coating. The coating material cost is in the moderate range, but the savings in solvent cost help to lower that.

Hot melt coating has some very strong advantages for a small firm (or one for whom pressure sensitive coating is just a sideline). The overall capital requirements are relatively low, and the space requirements are very small in comparison to either solvent-based or waterborne coating. This is convincing many converters who previously bought their pressure sensitive base stock to adopt in-house coating. This trend could result in the addition of many new small coating facilities, especially in the tag and label fields.

The greatest obstacle to the development of hot melt pressure sensitive tapes and labels is the limited range of thermoplastic (or thermosensitive) coating materials. Hot melts have been used successfully for adhesive coating. But the range of product properties which can be achieved is narrower than with waterborne coating, and much narrower than with solvent coating.[18]

The key to extending hot melt adhesive applications is the ability to induce crosslinking after the initial coating step. Intensive development work is underway to perfect this procedure. If successful, this would greatly improve the performance and range of application for hot melt pressure sensitive adhesives.[19] However, current experimental operations are using electron beam (EB) or ultraviolet (UV) cures which would mean a much greater capital cost for a new coating facility.

Hot melt coating facilities can be expected to continue to grow and extend their range of applications in the pressure sensitive tape and label industry. The growth can extend to include a significant portion of the industry. Detailed estimates of this growth are presented in Chapter 8. The speed of growth will be determined by technical developments that allow greater product substitution. Hot melt coating was used to some extent by 12 percent of the survey respondents in this study.

3.2.3.1 Process Description for Hot Melt Coating. The process of hot melt coating is simple in principle. The solid coating material must be melted and delivered to the coating head in the molten state. There it is metered onto the web generally by a slot-die type coater. The coated web is then chilled to restore the coating to the solid state. The web transport and tensioning are very similar to conventional coating, but simpler, due to the shorter length of web travel.

Despite the fact that hot melt coating equipment is cheaper and requires less space, many of its differences must be considered disadvantages. Manufacturers are hesitant to adopt new products and processes because of expected major startup and development costs. The equipment for hot melt coating is quite different from solvent-based or waterborne coating, and this difference has probably slowed its implementation, even in cases where product specifications could be met.

There are several real disadvantages associated with hot melt coating. It can be difficult to accurately control the coating weight. The coating head is more susceptible to streaking due to plugging or dirt accumulation. Cleaning the coating head is more difficult and time consuming. A product change is, therefore, more difficult. This puts more emphasis on longer runs, and reduces the flexibility of the coater. The hot adhesive tends to change properties over a period of time. This can be minimized by inert blanketing of the system and by limiting the amount of time spent at elevated temperatures.[20]

The range of applications for hot melt coating is limited by several factors. The adhesive coatings are of low to intermediate performance in terms of strength, heat resistance, and environmental stress. Hot melt coatings have a darker color which makes them generally unsuitable for transparent substrates. Heat sensitive substrates (such as the plastic materials) are also difficult to adapt to hot melt. Since the coating materials must be thermoplastic, the temperature range of product applications is more limited than with solvent or emulsion coating.[20] Many of these problems can be solved by developing a cross-linking methodology.

The energy requirements for hot melt coating are the lowest of any commercially available system (some of the radiation cured prepolymer systems promise even lower energy consumption). The key to this energy efficiency is that all the heat is concentrated on the coating. No heat is wasted on the large volumes of oven air or on the radiative heat losses from the massive ovens. Using conventional solvent-based coating as the basis for comparison, emulsion coating can reduce energy requirements by 82 percent while hot melts can achieve a 95 percent reduction.[21]

3.2.3.2 Sources of Emissions for Hot Melt Coating. Hot melt coating may be considered to be essentially pollution free. The possibility exists for the evaporative loss of some of the lighter components in the coating formulation. Most of the applicable coatings are high molecular weight polymers, which may contain trace amounts of unreacted monomers and/or lower molecular weight polymers. Some of these may be volatized at the coating temperatures experienced in hot melt coating. The EPA has conducted limited tests to measure evaporative losses from hot melt coatings. Various weights of hot melt smaples were heated at 320°F for periods of one hour, two and one-half hours, and five and two-tenths hours. Weight losses of from 0.1 to 12.6 percent occurred. Based on these results, all the samples would comply with a regulation equal to Regulatory Alternative III (stringent case).[22]

3.2.3.3 Existing Regulations and Emissions. Hot melt coating is governed by the same regulations as solvent-based coating. Eight states have included a specific exemption for hot melt coating systems. Emissions from hot melt coating should be low enough to meet the strictest existing regulations, so the exemptions just avoid the trouble of source testing to demonstrate compliance.

No realistic estimation of the current national emissions from hot melt coating can be made. It may be stated that hot melt emissions are a negligible part of the total emissions from pressure sensitive tape and label coating.

### 3.2.4 One Hundred (100) Percent Solids Silicone Release Coating

The development of a 100 percent solid silicone release formulation was forced by the same pressures as experienced with the hot melt adhesive and waterborne adhesive and release coatings. The first U.S. commercial operation was installed in 1975 and is still operating.[23] Both of the major silicone release material suppliers offer 100 percent solids silicone release formulations.[24,25]

The 100 percent solids silicone release materials have shown good release properties even with aggressive adhesives.[23] Release materials are not generally subject to wide variations in temperature, solvent resistance and cohesion properties as found in adhesives. Therefore, the 100 percent solids formulations can replace a significant portion of current solvent-based systems with minimal adverse effects in product quality. There is a very definite trend in the PSTL industry to switch from solvent-based systems to 100 percent solids (and also waterborne) silicone release coating. The conversion will probably be more rapid than the conversion of solvent-based adhesives to hot melt or waterborne adhesive coatings.

3.2.4.1 Process Description for 100 Percent Solids Silicone Release Coating. The coating of 100 percent solids release material can be done on existing solvent-based coating facilities. A gravure-type coater is recommended for release applications. An oven is required for curing the release solids. Oven temperatures are required to be as high as 260°C (500°F). It has been estimated that if a solvent-based coating line is converted to 100 percent solids, it can coat three to four times the amount of silicone at the same fuel supply rate. This is accomplished by:

- eliminating the drying cycle,
- recycling to a maximal 90 percent of air without explosion hazards,
- reducing the amount of coating to be heated by elimination of the solvent carrier, and
- minimizing the dwell time to as low as one (1) second at 260°C (500°F).

It has also been estimated that the overall annual operating costs of a 100 percent solids release system is less than a solvent-based system with solvent recovery.[25]

3.2.4.2 Sources of Emissions for 100 Percent Solids Silicone Coating. As with the hot melt coating operations, the 100 percent solids systems should produce negligible VOC emissions. There is a potential for emissions in the oven when 260°C (500°F) temperatures are experienced. Residual silicone monomers and other volatile materials can vaporize under these conditions. Through experience with solvent-based systems, there is a tendency for silicone materials to end up in oven exhaust gases. It is expected that these concentrations are very low.

3.2.4.3 Existing Regulations and Emissions. One hundred percent solids silicone coating is governed by the same regulations as solvent-based systems. No states specifically exempt 100 percent solids silicone, however, it can be assumed that emissions from this type of coating should be low enough to meet the strictest existing regulations.

No realistic estimation of current national emissions from 100 percent solids silicone coating can be made.

### 3.2.5 Solvent-based Precoat Coating

Precoat coating is defined as any coating operation performed on the web prior to its being coated with an adhesive or release material. Generally during precoating a primer, tackifier, saturant, lacquer, or other topcoat is applied to the web to impart certain qualities prior to adhesive or release coating. All precoating is currently applied with solvent-based technology, therefore, the potential for VOC emissions exists. Although it is being researched, the use of high solids technology for precoating is not available yet. The majority of precoating is performed as a precursor to the coating of an adhesive material. Not all tape and label products require a precoat. The desired characteristics and quality of the final product would determine the need for precoating.[26,27]

3.2.5.1 Process Description for Solvent-based Precoating. The coating of solvent-based precoats generally follows the same principles developed in Section 3.2.1.1 for solvent-based coating. Precoat formulations can be applied with the same coating line equipment used to coat adhesive or release formulations. The precoat station is located directly before the accompanying adhesive or release coating line. A drying oven is generally used on the precoat line to cure the coated web. LEL levels in precoat ovens average between 5 and 10 percent.[24] A typical arrangement for a precoat station is shown in Figure 3-8.

Precoat formulations are typically 5 to 6 weight percent solids and 90 to 95 weight percent solvent. The amount of solvent used is small because these coatings are applied in a very thin, low weight (about 0.23 kg per ream) coat similar to that of release coatings. Solvent consumption from precoating operations is less than 5 percent of the total solvent used in the overall production of a pressure sensitive adhesive product.

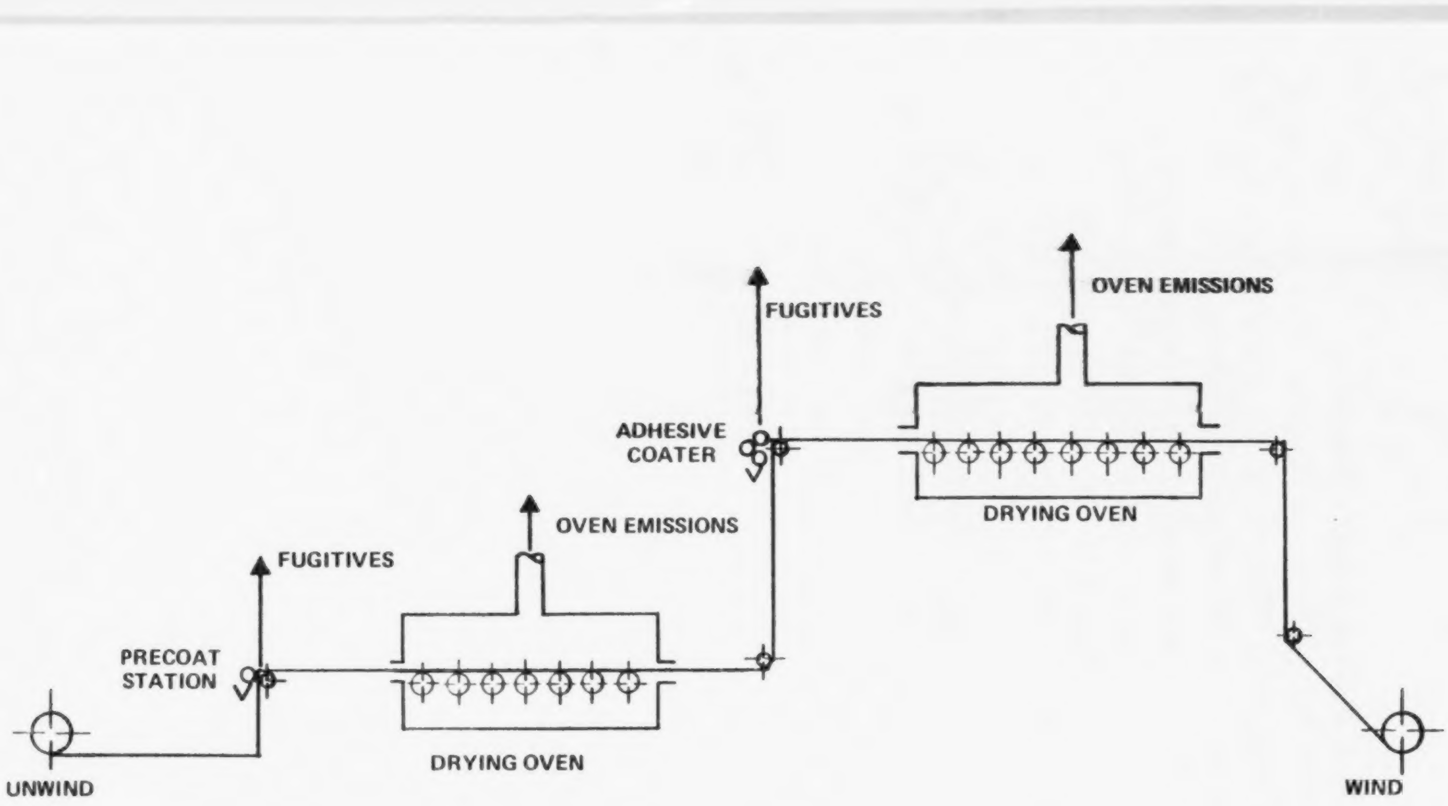

OVEN EMISSIONS
FUGITIVES
ADHESIVE COATER
OVEN EMISSIONS
FUGITIVES
DRYING OVEN
PRECOAT STATION
UNWIND
DRYING OVEN
WIND

Figure 3-8. Adhesive coating line operated in conjunction with a precoat station.

3.2.5.2 Sources of Emissions from Solvent-based Precoating. The primary sources of VOC emissions from solvent-based precoating lines are the coating applicator, flashoff area, and the drying oven. The drying oven exhausts constitute the largest single VOC emission source in precoating operations. Fugitive VOC emissions can occur at both the applicator and flashoff area. VOC emissions, particularly those from the drying oven, are either ducted to the atmosphere or to the adhesive coating line drying oven. Generally precoat emissions are subject to minimal control efforts.

3.2.5.3 Existing Regulations and Emissions. The same basic VOC emission limits that apply to solvent-based coating also apply to precoat operations. Currently no states grant emission exemptions to precoat lines. No realistic estimate of current national emissions from precoat operations can be made.

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# 4. EMISSION CONTROL TECHNIQUES

The pressure sensitive tape and label (PSTL) industry has significant emissions of only one type of pollutant, that being volatile organic compounds (VOC). These VOC are emitted as a result of the evaporative loss of solvent from two major sources:

- process emissions (exhaust from the drying/curing ovens)
- fugitive emissions (unintentional solvent evaporation from the coating operation itself).

This chapter will review the technology available for the control of these emissions.

There are five basic control technologies commonly used to reduce VOC emissions. Those technologies are:

- adsorption
- incineration
- absorption
- condensation, and
- process modification.

Of these five technologies, only carbon adsorption and incineration will be discussed in detail. Process modifications such as waterborne and hot melt coatings were covered in Chapter 3. Neither absorption nor condensation appears economically effective in the low VOC concentration range typical of pressure sensitive product coating.

Carbon adsorption and incineration would be considered equivalent in overall control effectiveness for reducing VOC emissions from pressure sensitive tape and label facilities. The selection of either of these control methods is dependent upon the specific application. When carbon adsorption can be applied without unusual operating problems, it usually holds an economic advantage because of the value of the recovered solvent.

There are many applications, however, where the auxiliary equipment necessary to recover and purify solvent would be so expensive that incineration becomes a better choice. The following is a list of general factors which would favor incineration (the absence or converse of these factors would therefore favor carbon adsorption):

- mixture of several solvents (which would require distillation and reformulation to reuse),
- coatings that give off relatively high levels of entrained particulates (which would foul and deactivate a carbon bed),
- water soluble solvents (which would require water treatment or some form of noncondensable regenerant), and solvents whose market value approaches their fuel value.

While both carbon adsorption and incineration are equally effective as "add-on" emission controls, they are not as effective as process modifications. Modifications such as waterborne emulsion coatings and 100 percent solids coatings hold a distinct advantage because of the total absence of solvent. This factor negates the difficult to control fugitive emission problem.

These alternate coating techniques have not, however, been sufficiently developed to replace solvent-based coating in many applications. For some specialty products, solvent-based technology may never be replaced. The use of solvent systems with add-on controls can fill this gap. Wherever applicable, alternate coating techniques hold a strong advantage in environmental, energy, and economic factors.

## 4.1 CARBON ADSORPTION

Carbon adsorption is a method of reducing VOC emissions by adsorption of the organic to the surface of activated carbon. The VOC are subsequently desorbed from the bed and recovered.

Carbon adsorption is a mature technology that has been applied to the control of VOC emissions from a wide range of industrial processes, including PSTL coating. Its theory and principles have been exhaustively covered in the literature. A very brief discussion of the operation of carbon adsorption units will be presented here, with emphasis placed on the specific applications in the PSTL industry.

### 4.1.1 Operating Principles

Although there are several types of continuous carbon adsorption units, most existing facilities use multiple fixed bed adsorbers which are cycled in and out of service. This results in a batch operation on any one adsorber, characterized by an adsorption mode and a regeneration mode. The operating discussion will be divided into these modes (see Figures 4-1 and 4-2).

In the adsorption mode, the gas containing VOC is routed to an adsorber containing freshly regenerated carbon. The VOC is quickly adsorbed onto the surface of the carbon, and the gas exits at a very low VOC concentration. As the capacity of the bed to hold VOC is used up, the exit VOC concentration begins to rise. This is called the breakthrough point, and it signals the need to switch the adsorber to the regeneration mode.

The important parameters during the adsorption mode include:

- degree of regeneration (or working capacity of carbon),
- VOC inlet concentration (% LEL),
- gas flow rate,
- cycle time,
- temperature of the inlet gas,
- type of solvent,
- type and amount of carbon,
- superficial velocity in the bed, and
- bed pressure drop.

The first six factors affect the variance of day to day operations, while the latter factors are generally set by the initial design.

There are two basic types of regeneration, thermal and low pressure. Both types are based on increasing the volatility of the adsorbed organic to the point where it leaves the surface of the carbon. Low pressure regeneration is best suited to units with very high VOC loadings, and it is not used to any extent in this industry. Thermal regeneration may be accomplished by either steam or hot air, with steam being almost

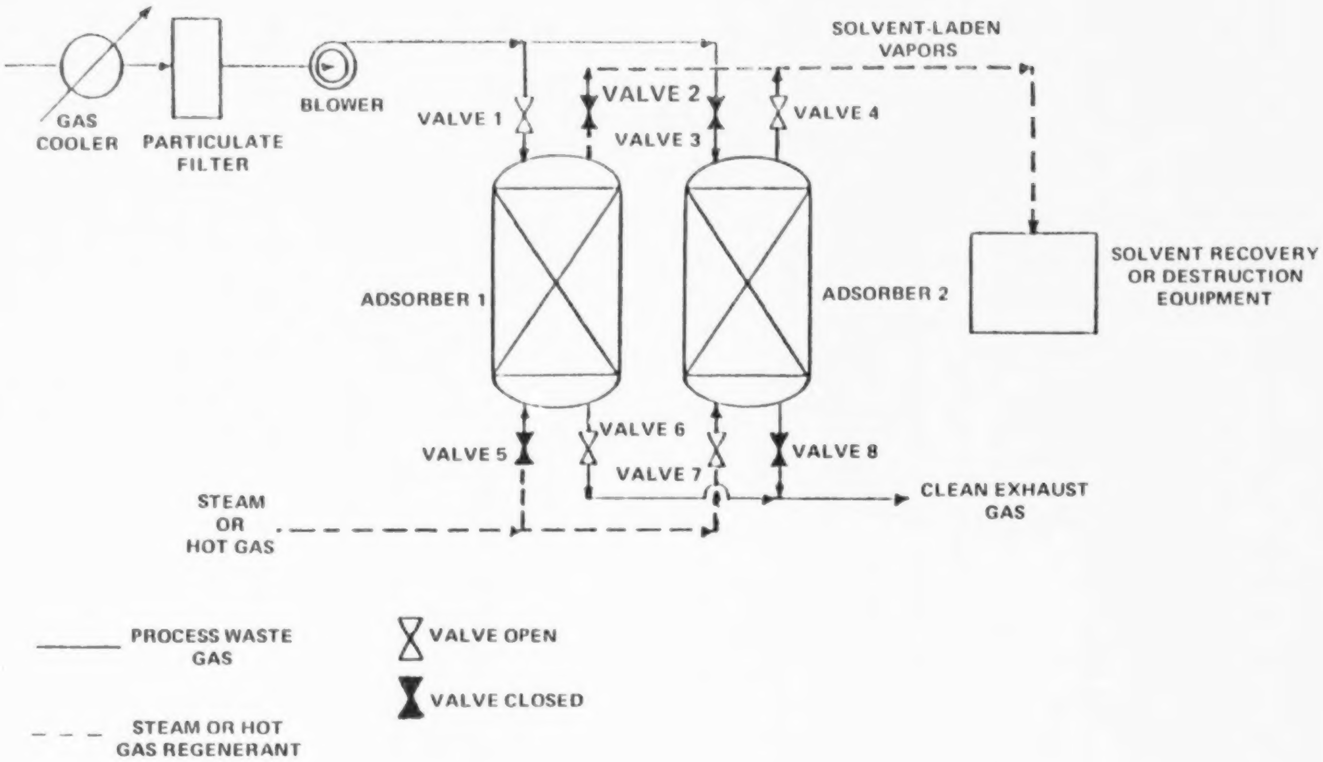

GAS COOLER
PARTICULATE FILTER
BLOWER
VALVE 1
VALVE 2
VALVE 3
VALVE 4
SOLVENT-LADEN VAPORS
ADSORBER 1
ADSORBER 2
SOLVENT RECOVERY OR DESTRUCTION EQUIPMENT
VALVE 5
VALVE 6
VALVE 7
VALVE 8
STEAM OR HOT GAS
CLEAN EXHAUST GAS
PROCESS WASTE GAS
STEAM OR HOT GAS REGENERANT
VALVE OPEN
VALVE CLOSED

Figure 4-1. Schematic of two-bed adsorber unit: adsorber 1 adsorbing, adsorber 2 regenerating.

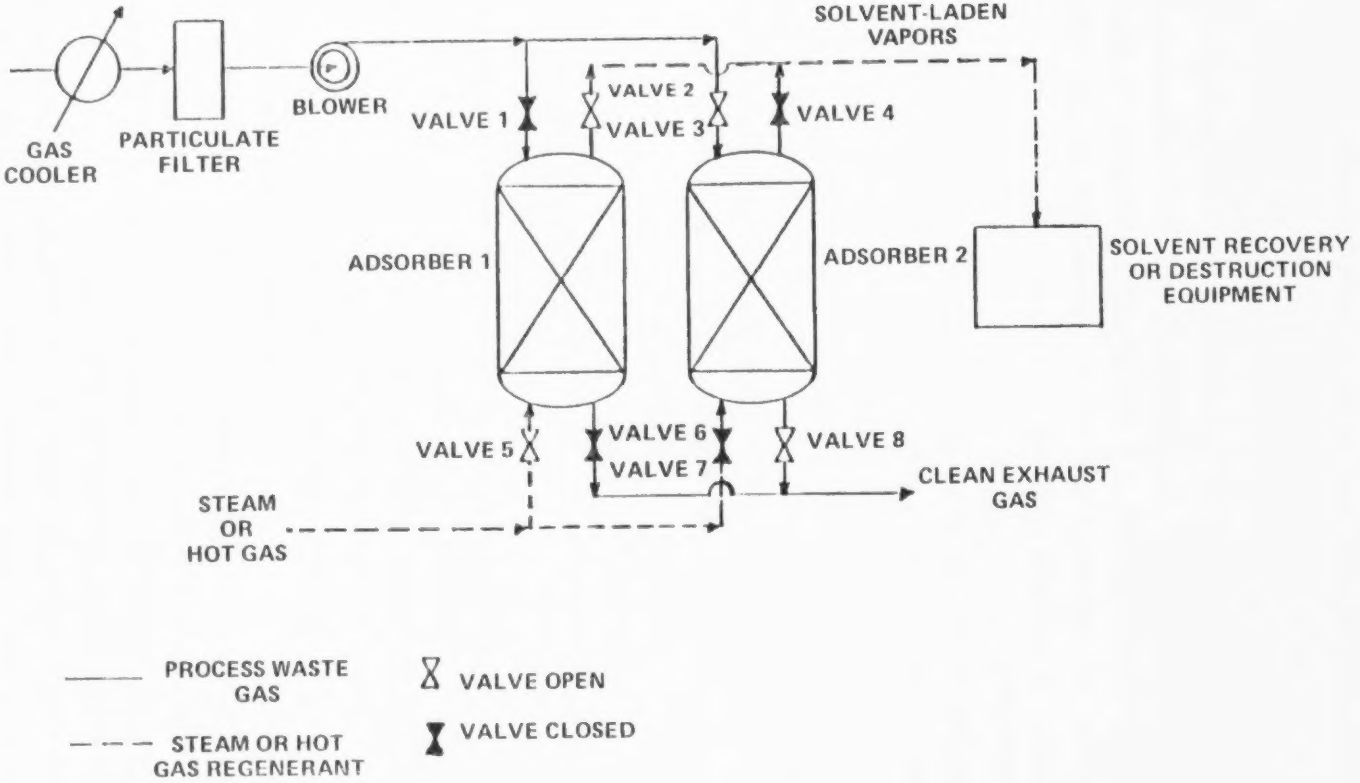

GAS COOLER
PARTICULATE FILTER
BLOWER
VALVE 1
VALVE 2
VALVE 3
VALVE 4
SOLVENT-LADEN VAPORS
ADSORBER 1
ADSORBER 2
SOLVENT RECOVERY OR DESTRUCTION EQUIPMENT
VALVE 5
VALVE 6
VALVE 7
VALVE 8
CLEAN EXHAUST GAS
STEAM OR HOT GAS
PROCESS WASTE GAS
STEAM OR HOT GAS REGENERANT
VALVE OPEN
VALVE CLOSED

Figure 4-2. Schematic of two-bed adsorber unit: adsorber 1 regenerating, adsorber 2 adsorbing.

universally used in PSTL coating applications. Hot air regeneration can be quite attractive when dealing with water soluble solvents.

The regeneration cycle is also illustrated in Figures 4-1 and 4-2. Steam is introduced to the bed which is loaded with adsorbed VOC. This results in desorption by both heating the bed and steam stripping. The combined water and organic vapors are condensed in a heat exchanger and routed to a decanter (see Figure 4-3). The organic and water layers separate in the decanter and are drawn off to storage or further treatment. The important operating variables during regeneration include:

- length of the cycle,
- pressure and degree of superheat of the steam,
- condenser water outlet temperature, and
- use of cooldown, drying, or expansion cycles before returning the bed to the adsorption mode.

### 4.1.2 Operating Problems

There are several areas of operating problems with carbon adsorption units in the pressure sensitive adhesive industry. Among these are:

- nonregenerable compounds fouling the bed,
- recovered solvent contamination,
- solvent/water separation, and
- corrosion.

Many operating problems are associated with high boiling compounds fouling the carbon bed. Monomers, low molecular weight polymers, resins, and tackifiers present in coatings tend to be picked up by the collection system.[1] Also, it has been theorized that iron (in the form of mild steel) used in equipment construction acts as a catalyst to form high boiling compounds in the carbon bed. One manufacturer tested this theory in laboratory glassware, and produced more than 20 identifiable heavy organics.[2] These heavy organic compounds foul the carbon beds rapidly, and because of their high boiling nature are not easily desorbed. This increases steam usage and shortens carbon life.

Vendors suggest that three kg steam per kg solvent (three pounds/pound) should be sufficient to regenerate the bed. They also indicate that

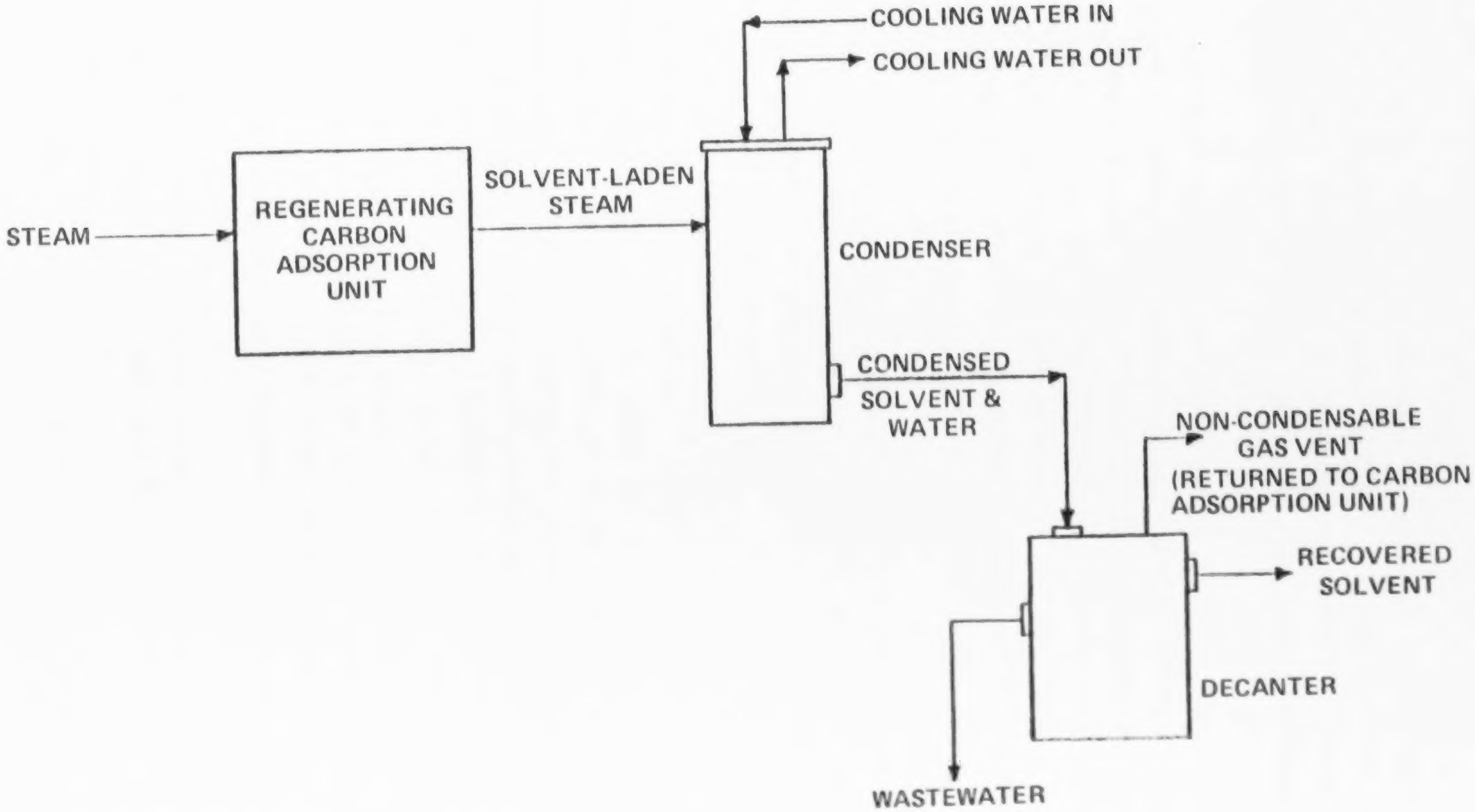

COOLING WATER IN
COOLING WATER OUT
STEAM
REGENERATING CARBON ADSORPTION UNIT
SOLVENT-LADEN STEAM
CONDENSER
CONDENSED SOLVENT & WATER
NON-CONDENSABLE GAS VENT (RETURNED TO CARBON ADSORPTION UNIT)
RECOVERED SOLVENT
DECANTER
WASTEWATER

Figure 4-3. Schematic of solvent recovery by condensation and decanting.

carbon life should be in the range of seven to ten years. Experience in the pressure sensitive adhesive industry indicates that these estimates are very optimistic. Steam requirements of up to six kg per kg of solvent (6 lb steam/lb solvent) were reported, as well as carbon life as short as six months.[1]

There are several problems associated with the use of recovered solvents. Multicomponent systems usually require distillation to separate the solvent components. These must then be reformulated to meet specifications. Even in single component systems, the recovered solvent may not be suitable for reuse. Trace materials may alter the solvent properties enough that it no longer meets specifications. One source reported that only 25 percent of recovered solvent could be substituted for virgin solvent.[1]

There are two options for disposing of recovered solvent that cannot be reused. The first is to sell this material back to the solvent supplier or an independent firm that specializes in reclaiming contaminated solvents. Payment for the spent solvent usually takes the form of a credit against fresh solvent purchases, and it is typically only about 30 percent of the virgin solvent price.[3] Another possibility is the use of recovered solvent as a fuel in the boiler or the coating ovens. Many of these devices are currently gas fired, however, and would require burner modifications before burning the solvent. There is little economic incentive to burn the solvent since most solvents cost a great deal more than fuel oil. Carbon adsorption is generally economically attractive only if the recovered solvent can be reused directly.

The formation of organic/water emulsions in the decanter may be a problem. Recovery of the emulsion with the organic layer has been used to avoid the need for water treatment facilities. The emulsified water is subsequently removed from solvent storage tanks and recovered by steam stripping or distillation.

Corrosion is often a problem in carbon adsorption systems. Most of the solvents used in the pressure sensitive adhesives industry are not intrinsically corrosive, but corrosive compounds may be formed in the bed. The process is similar to that previously described in the formation of high boiling compounds. This type of corrosion has resulted in the replacement of most of the internals and duct work of a carbon adsorption unit used by one pressure sensitive adhesives manufacturer after only three years of operation.[2] Also, processes which use direct-fired heaters may have problems with adsorbed carbon dioxide. On steam regeneration, the $CO_2$ combines with water to form carbonic acid.

Another potential problem is the occurrence of bed fires. These apparently result from spontaneous ignition of solvent on the carbon surface. Since adsorption is an exothermic process, it is possible that heat liberated in a dead spot (with no air flow to cool it) could rise to the auto-ignition temperature. The occurrence of bed fires is directly related to; (1) the oxidation properties of the particular solvent, (2) the air velocity through the bed, and (3) the design of the tank containing the activated carbon.[4] Fires are predominantly associated with the ketone solvents and are most likely to occur after fresh carbon is added to the bed.[5] PSTL coaters are able to use ketone solvents, however, because they have learned how to handle the operational problems these solvents can cause. To safely use ketone solvents continuous monitoring of the following factors is recommended: (1) the $CO/CO_2$ concentration, (2) the outlet adsorber temperature, (3) the steam flowrate, and (4) the performance of the air valves.[6] Generally, ketone solvents are used sparingly.

While all of these operating problems mentioned above seriously affect the economics and ease of operation, they can be overcome. One pressure sensitive adhesives manufacturer reports a carbon adsorption system which has been in operation 11 years. Replacements and downtime have been minimal; carbon life is averaging four years. Also, they are achieving an overall control efficiency near 90 percent.[7]

### 4.1.3 Existing Applications and Performance of Carbon Adsorption

The industry survey found eleven carbon adsorption units in operation in the pressure sensitive tape and label coating industry. Most of these units were built during the last 15 years and, therefore, are representative of relatively modern technology. Two of these units will be described in detail to illustrate the applicability of carbon adsorption to PSTL coating.

PSTL Manufacturer A installed a new carbon adsorption system in 1977 to control emissions from a 1.5 m. (60 inch) solvent based adhesive coating line. The solvent used is pure toluene, and the recovered solvent is recycled to the adhesive formulation process. The line produces a single product.

The unit is designed to handle 15.5 $Nm^3$/sec. (32840 SCFM) of combined oven exhaust gas only. The concentration of the combined inlet gas is controlled in the range of 20 to 40 percent of the Lower Explosive Limit (LEL). This results in a bed efficiency well in excess of the 96 percent guaranteed by the vendor. This unit achieves an overall efficiency of near 90 percent as measured by a solvent material balance.

Three fixed bed adsorbers are employed (with one adsorbing, one regenerating, and one cooling at any given time). The adsorption cycle lasts about 35 minutes. Cycle change is automatically initiated when the combustible gas monitor on the adsorber outlet exceeds the breakthrough setpoint or by a preset time interval. The carbon beds are regenerated with steam, and the combined steam/solvent vapors are condensed. The solvent is decanted, metered, and pumped to storage. The water layer is discharged to a city operated treatment plant.

Operating problems and equipment replacement have been minimal, both on the unit described above and on a similar unit in operation at the same plant for about twelve years. The new unit is still using the original carbon, and a four year carbon life is typical for the older unit. These units have consistently operated at a profit, and the economic incentive is growing with rapidly escalating toluene prices.[8]

PSTL Manufacturer B is also operating a carbon adsorption unit at their coating facility, but under much less favorable circumstances. This unit was installed in 1973 to treat 5.66 $m^3$/sec. (12,000 SCFM) of solvent laden air from four coating lines. These lines produce a wide variety of custom coated products, and consequently use a variety of mixed solvents.

This unit operates successfully from an environmental viewpoint. The oven exhausts are routed to the adsorbers at about 10 percent LEL.

The system has two fixed bed adsorbers switched on a 30 minute cycle. It easily achieves the 97 percent bed efficiency guaranteed by the manufacturer, and the overall efficiency has been measured to be in excess of 93 percent. Even the decanter water is caustic treated for pH control and recycled to boiler feed water.

On the negative side, this unit has experienced a variety of operating problems. Among these are bed fires, freeze damage, upsets due to power outages, carbon fouling by high boiling materials, and corrosion in the water system. Operating experience has, however, minimized the effects of these problems.

A more significant problem, however, is economic. The reuse of recovered solvent has not proved possible because of the wide range of solvents used. Recovered solvent is currently sold to a firm which distills and reblends the solvents. Although a small recovered solvent credit is received, it is not enough to cover the unit operating expenses.[9]

These two examples illustrate the range of carbon adsorption applicability to pressure sensitive tape and label coating. It is an acceptable emission control technology for almost all of the industry. In many cases, however, other control options may be more attractive from an economic viewpoint. The ability to reuse the recovered solvent is the key issue in the economic assessment. Although there are a number of potential operating problems associated with carbon adsorption, these problems have been overcome in many installations. Where carbon adsorption is economically attractive, it presents a good control option in terms of both environmental factors and resource conservation factors.

## 4.2 INCINERATION

The process of incineration involves the oxidation of organic pollutants to carbon dioxide and water. Incineration has been used extensively as an emission control technology in many industries including PSTL coating. It is a mature and well documented technology. This section presents a brief discussion of incinerator operation with emphasis on those factors that affect its application to PSTL coating emissions.

### 4.2.1 Operating Principles

The operating principle of incineration is basically just oxidation (or burning) of the pollutants. In thermal incineration, this is accomplished by exposing the solvent laden air to high temperature (540 to 820°C or 1000 to 1500°F) and possibly a direct flame for a period of 0.3 to 0.6 seconds.[10] The percent of VOC (solvent) destruction as a function of temperature has been well documented. Figure 4-4 shows the EPA's estimates of VOC reduction versus firebox temperatures.[11] Also on this figure are data from existing incinerators on PSTL manufacturing facilities. The agreement is quite good between the EPA values and the test values. Similar results can be achieved by catalytic incineration at lower temperatures (400° to 540°C or 750° to 1000°F).[12]

Typical thermal and catalytic incinerators are shown in schematic form in Figures 4-5 and 4-6, respectively.

The factors important to incinerator design and operation include:

- type and concentration of VOC,
- gas flow rate,
- preheat temperature,
- firebox temperature,
- supplemental fuel rate,
- residence time,
- efficiency of flame contact,
- burner type, and
- amount of excess air.

The first four factors are the primary operating variables, and they determine the fifth factor, the rate of supplemental fuel firing. The remaining factors are design parameters and are subject to only minor variations on a day to day basis.

Heat exchange equipment could be considered an optional accessory to the incinerator system, but with rising fuel prices, it has almost become a necessity. Heat recovery equipment is generally divided into primary and secondary recovery. Primary heat recovery is defined as the

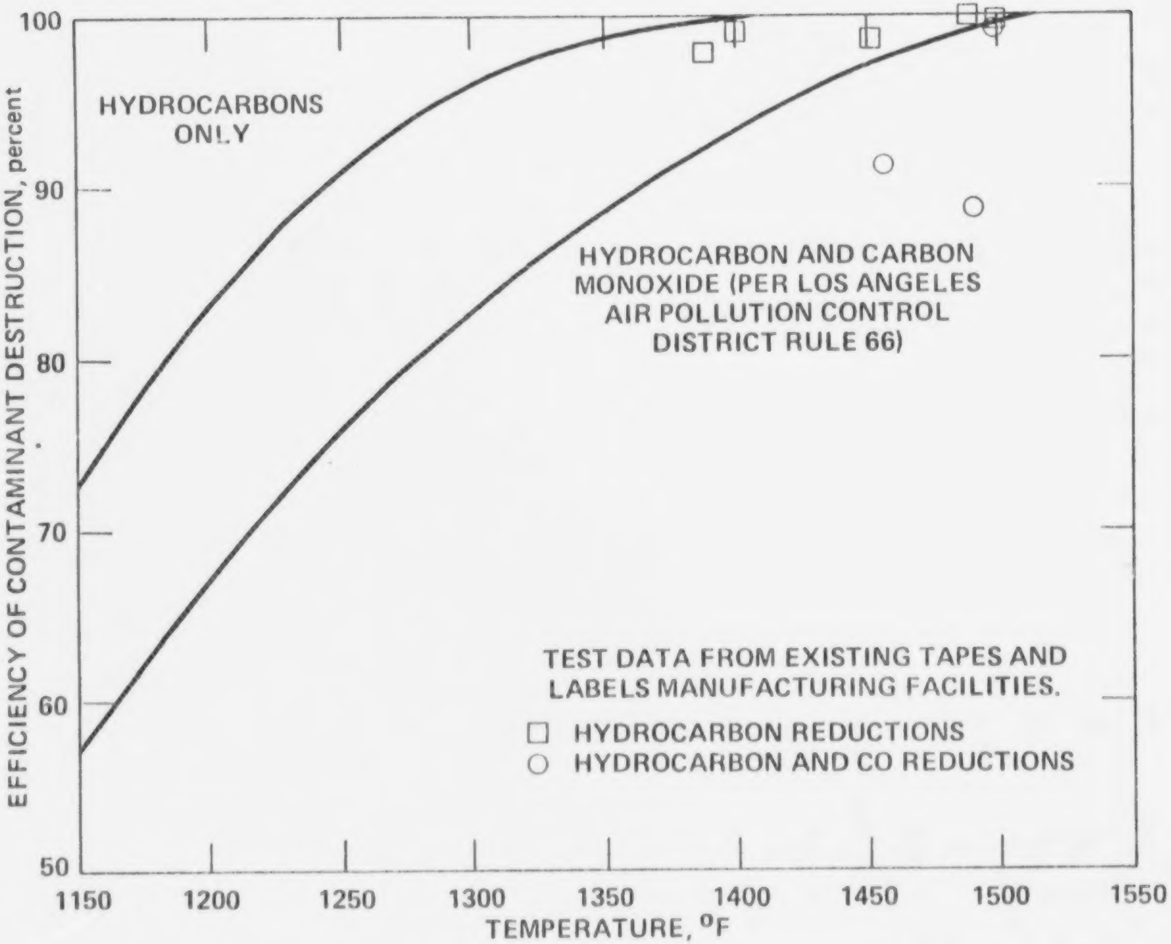


Figure 4-4. Typical effect of operating temperature on effectiveness of thermal afterburner for destruction of hydrocarbons and carbon monoxide. References 9,11,12,13, 14.

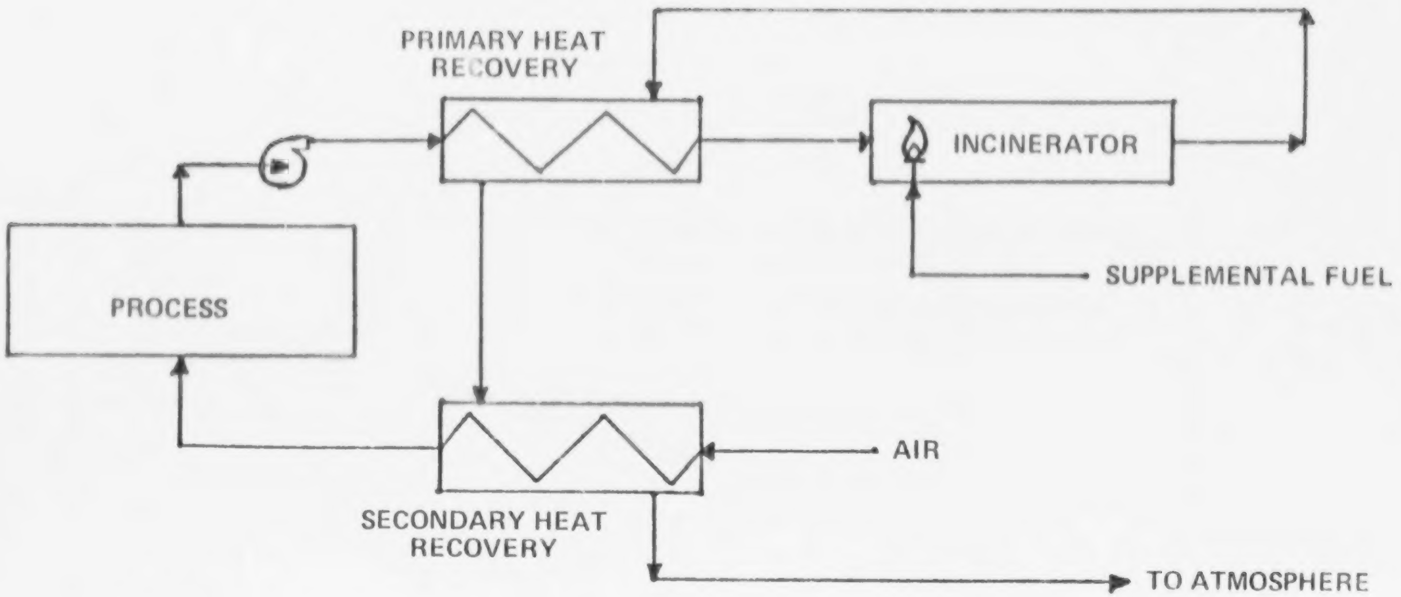

PRIMARY HEAT RECOVERY
INCINERATOR
SUPPLEMENTAL FUEL
PROCESS
AIR
SECONDARY HEAT RECOVERY
TO ATMOSPHERE

Figure 4-5. Incineration with primary and secondary heat recovery.

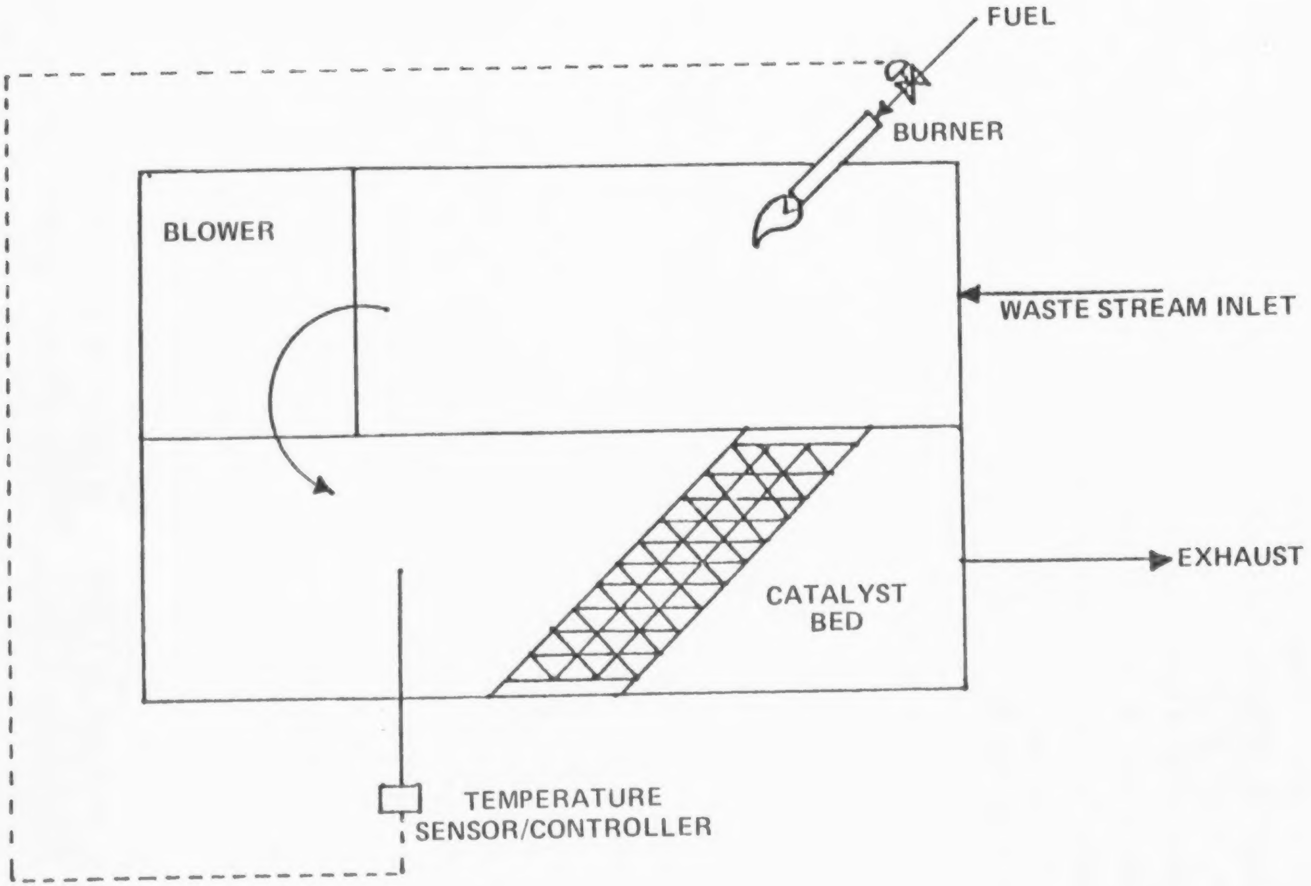

FUEL
BURNER
BLOWER
WASTE STREAM INLET
EXHAUST
CATALYST
BED
TEMPERATURE
SENSOR/CONTROLLER

Figure 4-6. Schematic diagram of a catalytic incinerator.

exchange of heat between the hot incinerator effluent and the relatively cool process waste stream. Secondary heat recovery is defined as any further exchange between the incinerator effluent and another process stream.

In describing a heat recovery system, the term efficiency is often used. This should be the thermodynamic efficiency of the system, or in other words, it represents the percent of available energy that is recovered. For a single air-to-air heat exchanger, this thermal efficiency may be approximated by:

$$\text{Exchanger Efficiency} = \frac{T_3 - T_2}{T_1 - T_2}$$

where $T_1$ = Inlet Temperature - Hot side
$T_2$ = Inlet Temperature - Cold side
$T_3$ = Outlet Temperature - Cold side

Primary heat exchanger efficiency (using standard tube and shell heat exchangers) is approximately 35 to 45 percent. The overall heat transfer coefficient for this heat exchanger is typically about

$$5.7 \text{ J/m}^2 \text{ sec °K } (1.0 \text{ BTU/hr ft}^2 \text{°F}).^{16}$$

This system is limited to about 45 percent efficiency not by heat exchanger design, but by safe operating practice. At 25 percent of the LEL, a temperature rise of up to 380°C (680°F) can occur on combustion. A maximum operating temperature of 820°C (1500°F) is typically specified to protect the incinerator and the heat exchangers.[17] This then limits the incinerator inlet temperature to about 440°C (790°F). This incinerator inlet limitation then limits the potential primary heat recovery efficiency. This also minimizes the possibility of auto-ignition of the waste stream in the primary heat exchanger. These primary heat recovery limitations are based on a concentration of VOC at 25 percent of the LEL. For lower concentrations, the safe limit for primary heat recovery increases. Below 5 percent of the LEL, 100 percent recovery would be safe (but, of course, technologically impractical).

Primary heat recovery in a catalytic incineration system is limited to a lower temperature by catalyst sintering and deactivation. The available heat in the incinerator exhaust is also lower, however, because of less sensible heat in the low temperature combustion products. This results in about the same primary heat recovery efficiency as thermal incineration.

A novel system of primary heat recovery has been developed using stoneware beds as the heat transfer medium. Incinerator exhaust gas passes through one stoneware bed, and transfers heat to it. The gas flow is then cycled such that incinerator inlet gas flows through that previously heated bed. The inlet gas is heated to near its ignition temperature by contact with the hot ceramic bed. It then enters an incineration section where it is exposed to a flame. The combustion products exit through another stoneware bed and their heat is recovered. The gases are periodically cycled (by temperature control) from one bed to the next.

Heat recovery efficiencies with this system are vendor guaranteed to 85 percent. Equipment to achieve 90 percent recovery is available as an option. This means that for concentrations above 5 percent of the LEL, supplemental fuel is required only to fire the pilot burner. Reductions of 90 to 97 percent in fuel requirements as compared to a thermal incinerator with no heat recovery are claimed.[18] Emission reduction efficiency is comparable to other incineration systems. If the inlet concentrations are substantially higher than 5 percent LEL, the system may be equipped with secondary heat recovery equipment.

Secondary heat exchange recovers waste heat for use in other processes in the plant. This energy may be used for process air heat requirements or for plant space heating. In coating facilities, secondary heat recovery could be used to heat inlet air to the curing ovens.

The overall heat recovery efficiency represents the total heat recovered from the incinerator exhaust stream compared to that which is available from the stream. If only primary heat recovery is used with an incineration unit, then overall heat recovery equals primary heat exchanger efficiency. With primary and secondary heat recovery, the overall heat recovery efficiency can be calculated by the following relationship to heat exchanger efficiency:

$$\begin{bmatrix}\text{overall heat} \\ \text{recovery efficiency}\end{bmatrix} = \begin{bmatrix}\text{primary heat} \\ \text{exchanger efficiency}\end{bmatrix} + \begin{bmatrix}1-\begin{pmatrix}\text{primary heat} \\ \text{exchanger efficiency}\end{pmatrix}\end{bmatrix}\begin{bmatrix}\text{secondary heat} \\ \text{exchanger efficiency}\end{bmatrix}$$

Heat exchanger efficiencies in secondary heat recovery are typically in the 50 to 55 percent range.[19] Assuming a primary heat recovery efficiency of 35 percent, this would yield an overall heat recovery efficiency of 70 to 80 percent. Typical overall heat transfer coefficients in the secondary heat exchanger would be about the same as mentioned earlier,

5.7 J/$m^2$ sec °K (1.0 BTU/hr $ft^2$°F).

It is possible for the energy recovered from solvent incineration to provide all of the energy needed for the incinerator and the drying oven, with supplemental fuel required only for a small pilot burner to prevent flame-out. This is, of course, highly dependent on the concentration of the VOC in the oven exhaust. No supplemental fuel will be required to incinerate air streams at 40 percent LEL or higher, while a more conventional concentration of 25 percent LEL will almost always require supplemental fuel. The exact break-even point will vary with solvent type and the desired firebox temperature. The maximum percent LEL is normally dictated by the company insuring the oven. A modern oven with LEL measurement meters can safely operate in the range of 50 to 60 percent LEL.

It should be pointed out that even for lower concentrations where some supplemental fuel is required, additional heat is available in the stack gases for further heat exchange. This is dependent on the availability of another heat requirement in the immediate area. Some possibilities for additional secondary heat recovery would include space heating for the building, boiler combustion air preheat, and oven heat for other coating lines. If the heat in the incinerator exhaust were used to the fullest extent, a net energy savings over the uncontrolled situation would result even if the incinerator requires supplemental fuel.

A novel form of secondary heat recovery is the use of oxygen-depleted incinerator exhaust gases directly in the curing oven. A schematic of this system is shown in Figure 4-7. In this system,

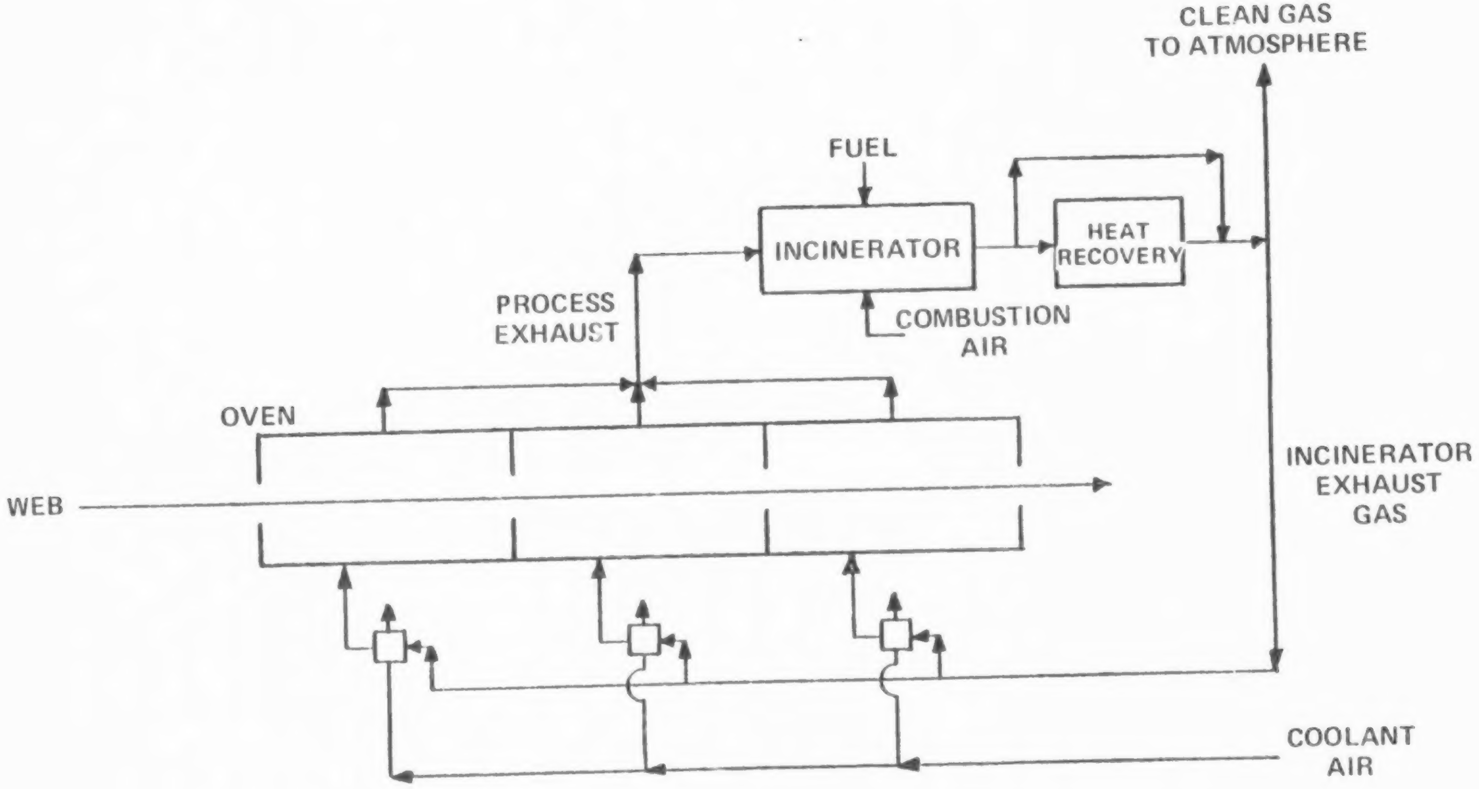

CLEAN GAS
TO ATMOSPHERE
FUEL
INCINERATOR
HEAT
RECOVERY
PROCESS
EXHAUST
COMBUSTION
AIR
OVEN
WEB
INCINERATOR
EXHAUST
GAS
COOLANT
AIR

Figure 4-7. Schematic of an inert recycle incineration system.

incinerator exhaust gases containing about two percent oxygen are recycled to the oven. Figure 4-8 shows that gases at this oxygen level are outside the explosive limit, regardless of the VOC concentration. As can be seen, the lowest oxygen level which will allow explosion is about 12 to 13 percent, so a large safety margin exists. This system uses oven oxygen monitoring equipment which sounds like an alarm when oxygen concentration increases past four percent and shuts the operation down when oxygen concentration increases to five percent.[20]

The oxygen depleted nature of the exhaust gases allows concentrations of solvent in the oven air to be much higher than 25% LEL. Because explosion cannot occur at low oxygen levels, solvent concentrations can be allowed to increase considerably. Much less dilution air is required, so fuel costs are significantly reduced. In conventional ovens, as much as 90 percent of the heat requirement is needed to heat the dilution air.

The admission of combustion air to the incinerator is controlled and limited to only that amount required to maintain stoichiometric combustion. The exhaust gases leaving the incinerator are at about 870°C (1600°F).[21] This stream is cooled to the desired temperature by heat exchange and returned to the oven. A small portion of the gases exiting the incinerator (equal to the combustion air volume and oven filtration) is routed to the atmosphere.

The overall heat recovery of this system is in the range of 85 to 90 percent, and results in the use of 70 to 90 percent less energy than a conventional oven. It should be stressed that this represents a reduction of process heat requirements, not just incinerator supplemental fuel. Here the process drying ovens and the incinerator are combined into a single system.

The emission control of the system is comparable to or better than conventional incineration. Testing on facilities in a closely related industry has shown a maximum VOC concentration of 50 parts per million by volume (ppmv) in the system exhaust. This exhaust rate is lower than on a conventional system because of the reduction in dilution air, resulting in very low emissions.

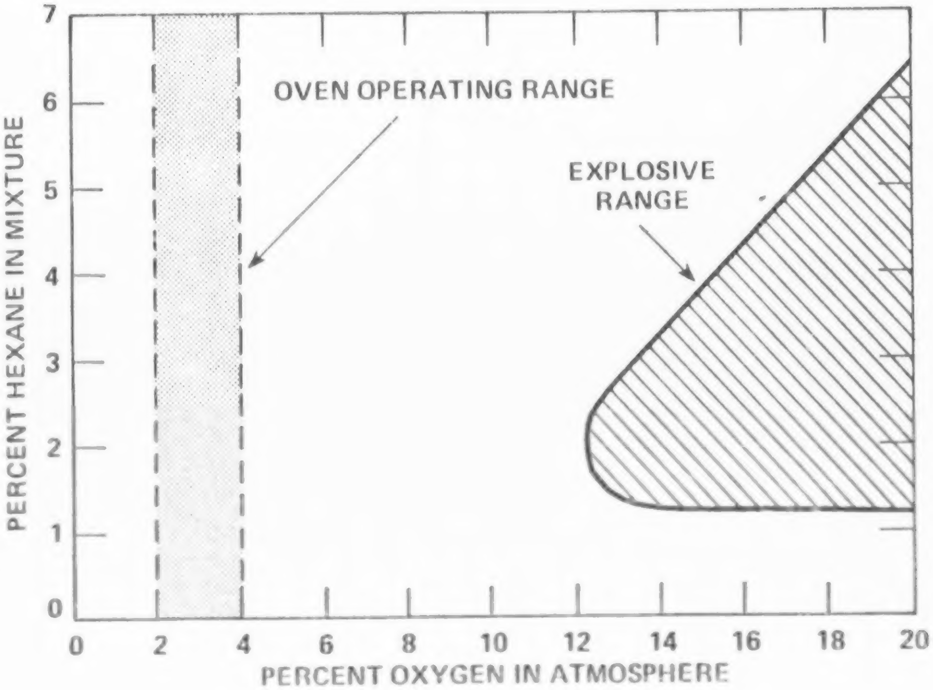


Figure 4-8. Explosive range of hexane-air mixture.

The inert air system is also offered as a combined incineration and carbon adosorption system. The highly concentrated VOC gases found in inert systems are ideal candidates for recovery by carbon adsorption. The carbon adsorber is run in-line with the incinerator with the exit gases from the carbon beds being fed to the incinerator. This type of arrangement will allow maximum solvent recovery and help minimize heat losses to the atmosphere.

### 4.2.2 Operating Problems

While incinerators are simple, reliable, and not prone to extensive operating problems, some of the potential problem areas include:

- low combustion efficiency of particulates,
- fouling of heat transfer surfaces,
- corrosion,
- catalyst poisoning,
- secondary emissions, and
- high operating cost with low LEL gas streams.

The process waste gas from adhesive drying ovens can potentially contain non-volatile organic particulates. These may include entrained particles of adhesive resins, additives, release compounds, etc. An incinerator designed to combust volatile organics may not have sufficient residence time to destroy these particulates. This is an insignificant problem from an environmental standpoint, since the emission rate of these particulates is usually very low.

A related problem is the fouling of heat transfer surfaces by deposition of these particulates, as well as others. Since the potential for this fouling does exist, regular monitoring of the heat transfer coefficients and cleaning should be done as required.

Most solvents used in the pressure sensitive adhesives industry will not cause corrosion problems on combustion. However, chlorinated solvents (which are seldom used) will produce highly corrosive compounds. Firing supplemental fuels with high sulfur content can also produce a corrosive atmosphere.

There are more potential problems with catalytic incineration than with thermal. The most serious of these problems is catalyst poisoning or deactivation. Some common catalyst poisons include phosphorous, bismuth, arsenic, antimony, mercury, lead, zinc, and tin.[22] Caution should be used in a catalytic incineration system concerning the use of phosphate metal cleaning compounds and galvanized ductwork. Also, certain silicone release compounds are prepared using an organometallic complex which could potentially be a catalyst poison.

A second problem in catalytic incineration is one of particulate matter. Combustion efficiency is reduced by inhibited contact between the catalyst active sites and the pollutant gases due to particulate buildup on the catalyst bed. Also, pressure drop is increased which increases utility requirements of the blower.

Any combustion source can potentially cause the emissions of unburned hydrocarbons, carbon monoxide, and nitrogen oxides. The emission levels of these secondary pollutants should be very low considering that an incinerator is designed specifically with complete combustion as the objective. The temperatures typically encountered are not high enough to promote significant production of nitrogen oxides. Therefore the magnitude of any secondary pollutants from incineration is far out weighed by the benefits of VOC reduction.

Low LEL gases can cause increased operating costs for incineration units. Low LEL gases result from air leakage into the gas ducting systems, the dilution of oven gases with other process gases, or poor turndown in process ovens. Air leakage can be minimized by proper maintenance of ducts and ovens. The dilution of solvent-laden, oven gases occurs when low LEL gas streams, such as those from fugitive control equipment or curing oven zones, are combined directly with the drying oven gases. This problem can be minimized through efficient oven design where low LEL gases are used as makeup air to solvent drying zones in the oven. Probably the greatest cause of low LEL gases is the inability of drying ovens to turndown burners, recirculation air, and exhaust gases to meet a wide range of solvent loadings. Equipment manufacturers report the oven burners generally have a 30 to 1 turn-down ratio while air flows can be turned down 10 to 1.[23] Special designs can be made where turndown is increased by shutting off oven zones.

The incineration unit operating costs are greatly increased when controls are used on low LEL gas streams. The increased costs come from added fuel costs. As previously mentioned, systems operating at 40 percent LEL can maintain high incineration temperatures with no additional fuels. However, many operations coat a wide variety of coatings with different solvent loadings. The result is varied solvent concentrations in the oven exhaust gases. As a hypothetical example, one system coats three different coatings which result in 10, 25, and 40 percent of the LEL in the drying oven effluent gases. If the effluent gas flowrate is the same in all cases, 11.2 $Nm^3$/sec (25,000 scfm); the resulting incinerator fuel requirements are no added fuel for the 40 percent LEL case, 8.0 liter/minute (2.1 gallon/minute) of number 2 fuel oil for the 25 percent LEL case and 20.5 liter/minute (3.3 gallon/minute) for the 10 percent LEL case. If the plant operates 2,000 hours per year for each coating, the added annual fuel costs are zero for the 40 percent LEL case, $189,000 for the 25 percent LEL case, and $297,000 for the 10 percent LEL case (for fuel at 75 cents per gallon).

### 4.2.3 Existing Applications and Performance of Incineration

The industry survey has found incinerators in use to control emissions from PSTL coating lines. Three of these will be described in detail to illustrate the range of sophistication in incinerator design and operation.

The fume incinerator operated by PSTL Manufacturer C is a good example of basic incineration with no attempt at heat recovery. This unit treats the solvent laden air stream from the exhaust of an adhesive coating line. This stream is about 3.3 $m^3$/sec. (7000 SCFM) at a concentration in excess of 40 percent LEL. With the firebox at 760°C (1400°F), this unit achieves a destruction efficiency of about 97.5 percent. No estimate of overall efficiency was available. This unit did require supplemental fuel, but the firing rate was not specified.[24]

This unit represents a baseline application of incineration since no facilities are provided for heat recovery. It should be noted that Avery International has experimented with heat recovery on a similar unit, and rejected it because of severe fouling problems. The result is a unit that meets all environmental requirements but that is expensive to operate. The high VOC concentrations in the oven exhaust will help to minimize supplemental fuel requirements.

The incinerator used by PSTL Manufacturer D is slightly more sophisticated by virtue of the use of primary heat recovery. This unit treats a stream of exhaust gases from several coating lines. The organics are mainly toluene, xylenes, and ethyl acetate. The incinerator is designed to handle 3.8 $m^3$/second (8000 scfm) of 40 percent LEL exhaust gas with a 0.6 second residence time and firebox temperature of 788°C (1450°F). This results in a guaranteed efficiency of 90 percent, but no test data was available to establish the exact efficiency.

This incinerator is equipped with a two-pass preheater exchanger that would heat the oven exhaust from about 94°C (200°F) to a design value of 517°C (963°F). This would result in an energy savings of 6.1 GJ/hr (5.8 X $10^6$ BTU/hr). Unfortunately, that savings is seldom fully realized because of severe fouling problems. Many of the coated products produced at this facility are silicone based. Carry-over of silicones to the incinerator results in the deposition of a silica scale on the hot side of the preheat exchanger. This requires a one day downtime every three weeks for cleaning and has resulted in a planned replacement of the preheater after less than five years service. The new preheater will be designed to facilitate cleaning, thus minimizing downtime and maintenance labor charges.[25]

The incinerator operated by PSTL Manufacturer E is a good example of secondary heat recovery. This unit treats a 3.3 $m^3$/sec (7000 SCFM) stream of 20 to 40 percent LEL exhaust gas from a release coating oven. The solvent used is a mixture of alcohols. The incinerator has a destruction efficiency of better than 85 percent at a 650°C (1200°F) firebox temperature.

This unit is equipped for primary and secondary heat recovery. In addition to exhaust gas preheat, the incinerator effluent is used to heat the release coating oven and for space heating in the winter. The incinerator requires supplemental fuel to achieve the high firebox temperature, but a net fuel savings is achieved after accounting for oven and space heat recovery.[26]

## 4.3 VAPOR COLLECTION SYSTEMS

The design of the vapor collection system is very important to the overall emission reduction from a given facility. Control equipment can only recover or destroy those emissions which are captured and routed to it. Fugitive emissions escape directly. Only proper collection system design can minimize these fugitive emissions.

An efficient collection system should maximize the capture of fugitive emissions while minimizing the capture of dilution air. Since these are opposing functions, there should be an optimum degree of collection. This section will identify those factors important in collection system design, and qualitatively address the optimum degree of collection.

The factors important to the efficiency of a collection system include:

- degree of turbulence,
- capture velocity,
- selectivity of collection, and
- degree of containment.

Although these factors are interdependent, each one will be discussed separately.

It is obvious that turbulence in the air around a fugitive emission source will make effective collection much more difficult. Sources of turbulence that should be recognized and minimized (within operating constraints) include:

- thermal air currents,
- machinery motion,
- material motion,
- operator movements,
- room air currents, and
- spot cooling and heating of equipment.

The velocity necessary to collect contaminated air and draw it into an exhaust hood is called the capture velocity. At capture velocity, the inflow of air to the hood is sufficient to overcome the effects of turbulence and thereby minimize the escape of contaminated air. Empirical testing of operating systems has been used to develop the guidelines for capture velocity presented in Table 4-1.[27]

The selectivity of a collection system is as important as its overall efficiency. Selectivity describes the ability of the collection system to capture pollutants at their highest concentration by minimizing the inflow of clean air. A highly selective system will require less power to achieve a given collection efficiency, and the higher concentrations can have a great benefit in the subsequent treatment of the collected vapors.

One method of improving selectivity is the use of flanges in hood design to minimize air flow from areas of low concentration. This technique can reduce dilution air by as much as 25 percent.[28]

Flanges can also lower the pressure drop at the hood by altering its coefficient of entry ($C_e$). The value of $C_e$ is a measure of the degree of turbulence caused by the shape of the opening. A perfect hood with no turbulence losses would have a $C_e$ equal to one. Table 4-2 gives coefficients of entry for selected hood openings.[29]

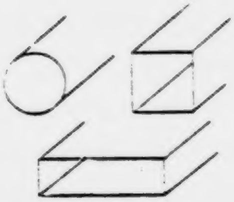
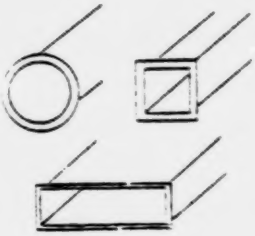
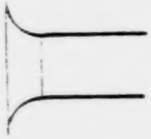
The final and potentially the most important factor is the degree of containment that the collection system has around the source of emissions. Ideally that source should be isolated in an air tight container with an exhaust into the collection system. A practical example that comes close to this ideal would be an automatic paint spray booth. Operating constraints require a higher circulation through the spray booth than would be optimal for collection selectivity, but the booth does provide a total containment of the pollutants.

The area between the coating head and the oven may be difficult to totally contain because of the need for operator access. Several types of hoods have been used with mixed results to collect fugitive emissions from the coating head area. One of the most common is the canopy hood.

Table 4-1. RANGE OF CAPTURE VELOCITIES

| Condition of dispersion of contaminant | Capture velocity m/s (fpm) |
|---|---|
| Released with little velocity into quiet air | .25 - .51 (50-100) |
| Released at low velocity into moderately still air | .51 - 1.02 (100-200) |
| Active generation into zone of rapid air motion | 1.02 - 2.54 (200-500) |
| Released at high initial velocity into zone of very rapid air motion | 2.54 - 10.2 (500-2000) |

Table 4-2. COEFFICIENTS OF ENTRY FOR SELECTED HOOD OPENINGS

| Hood Type | Description | $C_e$ |
|---|---|---|
|  | PLAIN OPENING | .72 |
|  | FLANGED OPENING | .82 |
|  | BELL MOUTH INLET | .98 |

This is a hood whose opening is about the same shape as the exposed web and is suspended at 0.3 to 1.5 meters (1.0 to 4.5 feet) above the web. This large opening would require a tremendous flow rate to achieve good capture velocities, but this can be improved by blanking off most of the center section. The large distance from hood to web makes it easy for turbulence to scatter some of the fugitive emissions. This hood is really effective only for solvent vapors that are considerably lighter than air.

Several alternate hood designs are available for vapors heavier than or about the same specific gravity as air. The first of these is the floor sweep, which, as the name implies, is a hood that takes suction near the source at floor level. Here again the web to hood distance is too large for very efficient collection. The slotted hood design remedies that. Here a slotted duct is run along each edge of the exposed web and draws air across the web into the hood.[30] An additional VOC capture device is the vacuum belt, which draws air down through the web to a hood underneath the web transport mechanism. In both the slotted duct and vacuum blanket controls, the captured VOC can be routed back into the drying ovens.

Much of this discussion of hood efficiency has centered on selectivity, collecting fugitive emissions at the highest possible concentration. This is very important if the collected streams are routed directly to a control device, but several coaters are using what appears to be a better alternative. They are using the air from the hoods as the combustion air for the drying ovens. By this method, some of the collected fugitive emissions may be consumed in the oven burner. Those not consumed exit from the ovens to the control device without introducing any additional dilution air. No increase in the size of the control device is necessary because no additional dilution air was introduced. This technique is also applicable to ovens using indirect heat sources such as steam or electricity.

There are limitations on this option as well. The amount of makeup air required by the oven may be too low to provide a high enough capture velocity for an extensive collection system. Oven burners currently using natural draft induction for combustion air could encounter this problem. Such burners would require the addition of a blower to successfully implement the fugitive collection system. Potential fluctuations in the VOC concentration of the collected gas also limits the degree to which the hood gases can be used as makeup air. Variations in oven temperature (caused by concentration fluctuations) can affect the overall drying operations of the oven. A sophisticated burner control system, equipped with concentration monitors, would be required to compensate for any temperature anomalies. Despite these operational problems, this option appears to be one of the most promising methods of fugitive emission control.

One PSTL manufacturer has extended this concept to include total containment. The coating lines are enclosed in a room which is maintained at a slight vacuum by drawing all oven combustion air from inside the room. A booster blower is used to move the oven exhausts to the carbon adsorption unit, resulting in the ovens running at a slight negative pressure with respect to the coating room. The result is a totally contained collection system that can approach 100 percent collection efficiency without diluting the solvent-laden air stream to the control equipment.[31]

In contrast to totally enclosing the coating line (or coating room), some coating firms only enclose their coater to contain fugitive emissions. This study identified and examined two such firms. One of these companies is involved in coil coating operations and the other in zinc oxide paper coating. Each operation uses a totally enclosed structure around their coater. The structure itself contains the majority of escaping fugitives. Fans and hoods inside the enclosure are used to vent the fugitive emissions (trapped by the structure) to the ovens and from there to a control device. In both of these cases control was achieved by incineration.[32,33]

The enclosures at these two plants presented no problems to the operation of the coating lines. In addition to capturing the fugitives, the enclosure also acts as a safety mechanism. It minimizes the potential for explosions and other hydrocarbon-related work area problems. Both operators expressed satisfaction with the enclosure method. Through proper technology transfer, PSTL coaters should be able to capture their fugitive emissions in a similar manner.

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# 5. MODIFICATION AND RECONSTRUCTION

While New Source Performance Standards (NSPS) are intended primarily for newly constructed facilities, existing sources can become subject to an NSPS through either "modification" or "reconstruction." These terms are defined in detail in the Federal Register (40 CFR 60.14 and 40 CFR 60.15). A modification is any change in an existing facility that results in increased emissions. A reconstruction is any change in an existing facility to the extent that the fixed capital cost of the new components is 50 percent or more of the fixed capital cost of a comparable entirely new facility. To qualify as a reconstruction, the Administrator must demonstrate that it is technologically and economically feasible for the facility to reduce emissions to the level of the NSPS. Examples of possible modification and reconstruction in the pressure sensitive tapes and labels (PSTL) industry are also discussed in this section.

## 5.1 MODIFICATIONS

A modification is defined as any physical or operation change to an existing facility that causes an increase in emissions. An affected facility is defined here as a single coating line. Whether or not an increase in emissions has occurred can be determined by:

- Application of emission factors from AP-42 or other emission factors determined to be satisfactory by the Administrator. These factors must demonstrate that emissions "clearly increase" before an existing source is considered to be modified.

- If emission factors are unavailable or do not give a clear indication of emission changes, material balances, monitoring, and/or emission testing may be required. This procedure requires three test runs before modification and three after, with all operating parameters held as constant as possible.

A number of exemptions and exceptions to the modification provisions are listed. It is stated in 40 CFR 60.14 that the addition or modification of one facility at a source will not cause other unaffected facilities at that source to be subject to NSPS provisions. Other provisions include:

- routine maintenance, repair and replacement,
- production increases achieved without any capital
- expenditure,
- production increases resulting from an increase in the
- hours of operation,
- addition or replacement of equipment for emission
- control (as long as the replacement does not increase
- emissions), and
- relocation or change of ownership of an existing facility.

The following paragraphs will list potential modifications in the pressure sensitive tape and label industry, and how they relate to the proposed NSPS.

The productivity of a coating line used to produce pressure sensitive adhesive products is determined by the web width, the line speed, the hours of operation, and the efficiency of scheduling. This industry has historically experienced a steady growth. Production increases to accommodate that growth can be accomplished by two methods. In the first method, the operation of the existing equipment is pushed to its capacity by debottlenecking, more efficient scheduling, and increasing the hours of operation. When no more capacity can be achieved in this manner, new coating lines are built or existing lines are upgraded. Most of the production increases (and the associated emission increases) from method one activity are specifically exempted from NSPS compliance. Most of the equipment modifications in method two involve totally new sources, or investments so large as to qualify as reconstruction. Specific examples are given below, with emphasis on the few cases where the modification clause might apply.

### 5.1.1 Changes in Web Width

Changes in the width of web (backing material or substrate for the tape or label) would increase both production and emissions. The maximum web width that any given coating line can handle is an integral part of the basic design of the line. This cannot be increased without installing essentially all new equipment. If an increase in web width was desired, it would normally be more attractive to build a totally new line than to modify an existing line. If such a modification were to be made, the cost would very likely be high enough to fall under the reconstruction provisions.

### 5.1.2 Changes in Line Speed

An increase in line speed is the most likely change that could constitute a modification.[1,2] The maximum line speed for a given facility depends on both the basic design of the coating line and on the specifications for each product coated. The factors which might constitute a line speed limitation include:

- a limitation on the available power and/or speed of the motors which drive the web,
- drying limitations based either on the amount of heat available or on residence time in the oven,
- a limitation on oven circulation which causes the Lower Explosive Limit (LEL) to be exceeded,
- a limitation on the maximum speed at which a smooth coating can be achieved with a given coating head/type of coating combination, and
- a limitation due to fragility of the web.

For a given coating line, the maximum line speed will differ between products, and the limiting equipment factor may differ also. Any equipment changes (such as larger/faster drive motors, higher capacity burners for the ovens, higher capacity oven circulating blowers, LEL sensors with alarm/shutdown capacity, or a change in coating head) which might be made to increase line speed, would require capital expenditure and result in increased emissions. As such, they would be modifications which would require that facility to comply with NSPS.

Many changes in product specifications (such as type of backing, type of coating, coat weight) could alleviate an equipment limitation resulting in a production increase. Some combinations of these changes could also result in increased emissions. They would not be termed modifications, however, since no capital expenditure would be required.

### 5.1.3 Changes in the Hours Available for Operation and/or Scheduling Efficiency

A typical pressure sensitive coating plant runs coating operations from 120 to 140 hours per week. Significant increases in production and emissions could result from extending the working hours, but this is specifically exempted under the modification clause.

Even during the hours of operation, a coating line must often be shut down or slowed down. This might be done to remove a finished roll of product and add a fresh roll of backing, to splice a broken web, or to make an adjustment at the coating head. Each time a change is made in the type of product to be coated on a given line, time must be allowed to clean up the equipment and to reset the controls to the new product specifications. Any given pressure sensitive product potentially receives several different coats in its production (adhesive, release coat, primer, pigment, and saturating agent). All of these factors indicate that careful scheduling can increase production which will result in increased emissions. This process would not be a modification because it requires no capital expenditures.

## 5.2 RECONSTRUCTION

An existing facility is subject to NSPS upon reconstruction regardless of any change in the rate of emissions. Reconstruction is defined as the replacement of components of an existing facility to the extent that the fixed capital cost of new components is greater than 50 percent of the fixed capital cost of a comparable entirely new facility. To qualify as a reconstruction, the Administrator must demonstrate that it is technologically and economically feasible for the facility to reduce to the level of the NSPS. Fixed capital cost is defined as the cost of all depreciable components. If an owner or operator intends a modification whose budget might cause it to be termed a reconstruction, he should notify the EPA at least 60 days before construction begins. Based on the information in that notification, a judgment as to the applicability of NSPS will be made considering the following factors:

- a fixed capital cost of the modifications planned versus the fixed capital cost of a comparable entirely new facility,
- the estimated life of the revisions relative to that of a comparable entirely new facility,
- the extent to which the components being replaced cause or contribute to the emissions from the facility, and
- any economic or technical limitations in complying with applicable standards of performance.

Many of the changes mentioned in the section on modifications would likely be high enough in cost to qualify under reconstruction. Any change of equipment to increase web width would require such massive equipment replacement that it would certainly be termed construction. It is doubtful that this would occur, however, since the plant could build a totally new line almost as cheaply and still retain the capacity of the old line. Only in the case of a severe space limitation, or if the existing line were totally inoperable, would this type of reconstruction be considered.

Several of the equipment changes to increase line speed could conceivably be costly enough to be termed a reconstruction. This would be most likely in the case of a severe drying limitation which might require the addition of one or more oven zones. Many of the smaller investment options (such as higher capacity burners, larger circulating blowers, high speed drive system, or instrumentation to allow operation at a higher percentage of the LEL) would not meet the guideline of greater than 50 percent of new construction cost. Combinations of these items could conceivably be costly enough to be termed reconstructions.

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# 6. MODEL PLANTS AND REGULATORY ALTERNATIVES

The main purpose of this chapter of the BID is to define the model plants and the regulatory alternatives that can be applied to them. For this study, a facility is designated as a single coating line. A single coating line consists of a coating head and thermal drying oven and the area in between. Other pieces of equipment such as wind and unwind stations may be included but are not VOC emission sources. For systems which have more than one coating line in series, each coating line will be considered as a single facility. The model plants will consist of various types and sizes of single coating lines or lines with two or more coating operations in series. The regulatory alternatives represent various courses of action the EPA could take towards controlling the VOC emissions from tapes and labels manufacturing facilities. Because the alternatives apply to release coating and adhesive coating operations, both types of technology are examined. The release coating operations are represented by silicone-solvent systems, while the adhesives systems would be typical of rubber resin-solvent or acrylic-solvent systems. The model plants derived in this Chapter are used later in Chapters 7 and 8 to determine ultimate environmental, economic, and energy impacts associated with applications of regulatory alternatives.

No model plants were specifically developed for solvent-based precoat coating lines. Because precoat lines are very similar physically and operationally to silicone release coating lines, a complete precoat model plant study would have been essentially a duplication of effort and information. Silicone release and precoat lines have similar coating weights (about 0.23 Kg per ream) and similar coating formulations (5-10 weight percent solids and 90-95 weight percent solvent). The technical model plant assessment and the economic analysis (Chapter 8) for silicone release lines would generally be true for precoat coating lines.

## 6.1 MODEL PLANTS

A complete characterization of an industry as complex as the pressure sensitive tape and label coating industry would require many cases. However, the models presented here are an attempt to find a limited, yet workable and meaningful set of cases. This resulted in a case matrix keyed to the following factors:

- web width (3 variations),
- line speed (3 variations),
- solvent type (2 variations),
- streams controlled (2 variations), and
- type of coating (2 variations).

The uniform application of all these factors results in a total of 72 cases. By judiciously trimming out meaningless cases and emphasizing those cases that illustrate some important points, the matrix was reduced to 12 model plants without significant loss in meaningful content. The next section describes in more detail each of the parameters.

### 6.1.1 Design Parameters

The major design parameter for a tape or label coating facility is production rate. The production rate is dependent on the line width and the line speed. Line widths are based on widths standard to the tape and label industry with 0.381 m (15 inch), 0.61 m (24 inch), 0.91 m (36 inch), 1.22 m (48 inch), 1.52 m (60 inch), and 1.83 m (72 inch) coating facilities being typical nominal values. For this study the 0.61 m (24 inch), 0.91 m (36 inch), and 1.52 m (60 inch) coaters were chosen to be representative as small, medium, and large width coaters, respectively. From observations of industry, the 60-inch coater is a very common large coater.

Line speeds in the industry vary quite substantially. Speeds from less than 0.05 meters per second (10 feet per minute) up to 5.1 meters per second (1000 feet per minute) can be found. In solvent-based systems line speeds are generally determined by the oven design. The ovens are designed to handle only a certain amount of solvent due to lower explosive limit (LEL) requirements. Once the LEL levels have reached a certain maximum level, the solvent removal, and thus the line speed, has been maximized. The line speeds used in the model plants study are assumed to be 0.13 m/sec (25 fpm), 0.3 m/sec (53 fpm), and 1.2 m/sec (230 fpm). These speeds are based on an average production speed which includes shutdowns, startups, and changeovers. For this study, the fast speed will be applied to the large-sized line, the moderate speed to the medium-sized line, and the slow speed to the small-sized line. This situation is representative of a large-sized line producing a high-volume product, while the medium and small-sized lines are more representative of the short run specialty coater operations.

Two solvent systems were chosen to roughly represent the wide range of solvents used in the industry. Toluene was chosen as the most common example of a solvent system using a single component solvent with a relatively high price. This type of system should strongly favor carbon adsorption. Varnish makers and painters (VM&P) naphtha was chosen as an example of a less expensive solvent, such as is commonly used in compliance with several SIP's in regard to photochemical reactivity. This type of solvent may tend to favor incineration, since its market price is only slightly higher than its fuel value. The naphtha solvent has a LEL value of 0.81 volume percent while toluene is 1.27 volume percent. Since it is assumed that the ovens operate at 25 percent LEL in all cases, the amount of dilution air will vary with solvent. This variance has a significant effect on the size of control equipment.

The model plant control strategies offer two methods for controlling VOC emissions from coating operations. The first method is to control oven emissions only. In this case the gases normally emitted directly to the atmosphere from the ovens would be routed through a control device. The second method is to attempt to capture fugitive VOC emissions around the coating head and route those emissions with the oven emissions to the control device. In the model plants it is assumed that the captured fugitive VOC emissions are used as either oven burner makeup air in the systems controlled by carbon adsorption units or as oven makeup air in systems controlled by incineration units. More discussion of equipment layout is given in Section 6.2.2.

The amount of fugitive solvent that is able to be captured by hoods is a very difficult number to quantify. Fugitive solvent is defined as any VOC which vaporize and are emitted to the work area before entering the oven. The fugitive solvent problem is also complicated by the possibility of slower lines producing more fugitive VOC per square meter of product than faster lines. If one assumes that the distance from the coater to the oven is the same for all sized lines, the web on a faster line is exposed to the outside environment for a shorter period of time than a slower line. Therefore, the total emission rate may be the same from fast and slow lines. But the production is higher for a larger line which results in a lower relative percentage of fugitive solvent loss. A further discussion of this point along with a quantitative estimate of the expected VOC emissions is given in the next section on model plant parameters.

The two types of coatings examined for the model plants are adhesive coatings and silicone release coatings. The adhesive coating is based on a 33.3 weight percent solid formulation with the remainder being solvent. In a 1978 survey of California tape and label manufacturers, this was the approximate average solids content of adhesives being used at that time.[1] The adhesive coating thickness is assumed to be 0.047 kilograms per square meter (28 pounds per 3000 square feet) based on the weight of the coated adhesive solids. The silicone release coating is based on a formulation containing 5 weight percent solids and 95 weight percent solvent. A 1979 Radian survey of silicone release sheet coaters indicated that this weight percent is typical of present solvent silicone release operations.[2] The weight of the coated silicone release is assumed to be 0.00081 kilogram per square meter (0.5 pound per 3000 square feet) based on the weight of the coated release solids.

### 6.1.2 Model Plant Parameters

Table 6-1 illustrates the combinations of variables for the 12 model plants. In this section material and energy balances are calculated for each model plant. Figure 6-1 shows a typical tape or label coating facility without a control device. This coating facility can be

Table 6-1. MATRIX OF MODEL PLANTS WITHOUT CONTROLS

| | Line width-m (inches) | | | Line speed-m/s (fpm) | | | Type of solvent | | Type of coating | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model Plant | 0.61(24) | 0.91(36) | 1.5(60) | 0.13(25) | 0.3(53) | 1.2(230) | Toluene | Naphtha | Adhesive | Silicone |
| 1 | X | | | X | | | X | | X | |
| 2 | | X | | | X | | X | | X | |
| 3 | | | X | | | X | X | | X | |
| 4 | X | | | X | | | | X | X | |
| 5 | | X | | | X | | | X | X | |
| 6 | | | X | | | X | | X | X | |
| 7 | X | | | X | | | X | | | X |
| 8 | | X | | | X | | X | | | X |
| 9 | | | X | | | X | X | | | X |
| 10 | X | | | X | | | | X | | X |
| 11 | | X | | | X | | | X | | X |
| 12 | | | X | | | X | | X | | X |

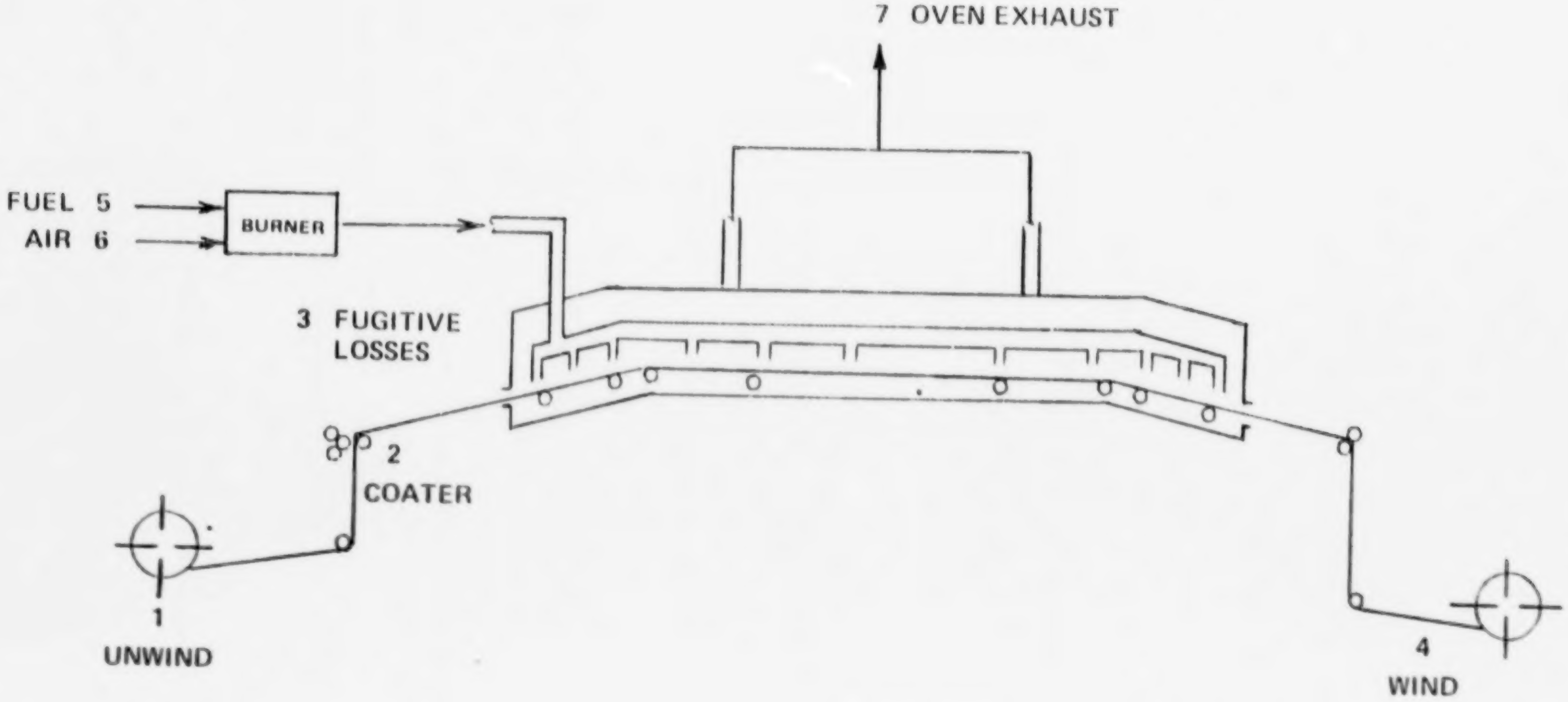
7 OVEN EXHAUST
FUEL 5
AIR 6
BURNER
3 FUGITIVE LOSSES
2 COATER
1 UNWIND
4 WIND

Figure 6-1. Typical tape or label solvent coating facility.

for either adhesive or release coating. The material balances in this section are based on this type of coating configuration.

To calculate the material and energy balances around a coating facility several assumptions need to be made. Table 6-2 lists the assumptions used in this study. The major assumption concerns the ultimate fate of the solvent. The solvent retained in the product is expected to be low. Industrial sources indicated it will be from one to five percent of the solvent in the original applied coating.[6,7,8] For this study the value is assumed to be one percent.

The quantitative estimates for the fugitive solvent emission rates are made from theoretical estimates of solvent evaporation effects and also on the performance of existing controlled PSTL coating lines. As mentioned earlier, when compared to fast line speed facilities, the coating lines with slow line speeds may have a greater percentage of the total applied solvent result in fugitive solvent emissions. Industrial sources have mentioned this effect.[6] To quantify the fugitive emission rates, existing coating lines controlled by carbon adsorption systems are examined. Based on solvent in the coating and solvent captured in the carbon adsorber, the overall VOC capture performance of existing controlled coating lines ranges from 80 to 93 percent.[7,9,10] These same sources indicate that the amount of solvent in the carbon adsorber effluent gas ranges from less than one percent to near five percent of the total solvent used. Combining all of this data, and the data on solvent remaining in the coated product, the fugitive solvent emission rates can be estimated to be from 1 to 18 percent of the solvent applied in the coating. For the model plants, the percent of the total solvent applied which results in fugitive VOC is estimated at 15 percent for the slow line speed, 13 percent for the medium line speed, and 10 percent for the fast speed. The values are assumed the same for the adhesive and silicone release lines.

Using the assumptions in Table 6-2 and the design parameters in Table 5-1, the material balances for each of the 12 model plants can be calculated. Tables 6-3 and 6-4 represent the results of these calcula-

## Table 6-2. ASSUMPTIONS USED IN CALCULATING MODEL PLANT MATERIAL AND ENERGY BALANCES

(1) The adhesive formulation is 66.7 weight percent solvent and 33.3 weight percent solid adhesive. The specific gravity of the formulation is 0.935, the solvent is 0.863, and the adhesive is 1.14.

(2) The silicone formulation is 95 weight percent solvent and 5 weight percent silicone. The specific gravity of the formulation is 0.870, the solvent is 0.863, and the silicone is 1.0.

(3) The weight of the adhesive coat is 0.051 Kg/m$^2$ (0.094 lb/yd$^2$) and the weight of the silicone coat is 0.00081 Kg/m$^2$ (0.0015 lb/yd$^2$).

(4) The LEL for toluene is 1.27 volume percent and for VM&P naphtha is 0.81 volume percent.[3] The ovens operate at 25 percent LEL.

(5) All heat requirements can be met by heating the cool makeup air to 65.5$^o$C (150$^o$F) above the ambient condition (i.e. 27$^o$C to 92.5$^o$C).[4]

(6) One percent of the solvent remains in the coated product.

(7) The relative amount of fugitive VOC decreases with increasing line speed. For this study, the percent of total solvent applied which results in fugitive VOC is 15 percent for the slow line speed, 13 percent for the medium speed, and 10 percent for the fast speed.

(8) The fuel used in the oven burners is natural gas.

## TABLE 6-3. MODEL PLANT PARAMETERS - ADHESIVE COATING LINES WITHOUT CONTROLS

| Model Plant No. [a] | 1 | 2 | 3 | | | | | 4 | 5 | 6 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream Number [b] | Small Facility | Medium Facility | Large Facility | Toluene % LEL | Toluene ppmV | Temperature °C | Temperature (°F) | Small Facility | Medium Facility | Large Facility | Naphtha % LEL | Naphtha ppmV | Temperature °C | Temperature (°F) |
| 1. (Kg/hr) | 14 | 44 | 314 | | | | | 14 | 44 | 314 | | | | |
| 2. (KgVOC/hr) | 29 | 91 | 665 | | | | | 29 | 91 | 664 | | | | |
| (Kg/hr) | 57 | 180 | 1308 | | | | | 57 | 180 | 1308 | | | | |
| 3. (KgVOC/hr) | 4 | 12.9 | 60 | | | 27 | ( 80) | 4.3 | 10.9 | 58 | | | 27 | ( 80) |
| 4. (KgVOC/hr) | 0.3 | 1.0 | 6.7 | | | | | 0.3 | 1.0 | 6.7 | | | | |
| (Kg/hr) | 28 | 89 | 650 | | | | | 28 | 89 | 650 | | | | |
| 5. ($Nm^3$/sec) | 0.0014 | 0.0046 | 0.0354 | | | | | 0.0019 | 0.0061 | 0.0465 | | | | |
| 6. ($Nm^3$/sec) | 0.50 | 1.59 | 12.31 | | | 27 | ( 80) | 0.65 | 2.11 | 16.19 | | | 27 | ( 80) |
| 7. (KgVOC/hr) | 24.7 | 77.1 | 598.3 | | | | | 24.4 | 79.1 | 599.3 | | | | |
| ($Nm^3$/sec) | 0.52 | 1.64 | 12.74 | 25 | 3175 | 93 | (200) | 0.68 | 2.18 | 16.73 | 25 | 2025 | 93 | (200) |

[a] Model plant numbers refer to the model plants listed in Table 6-1.

[b] Stream numbers refer to the streams identified in Figure 6-1.

## TABLE 6-4. MODEL PLANT PARAMETERS - SILICONE RELEASE COATING LINES WITHOUT CONTROLS

| Model Plant No. [a] | 7 | 8 | 9 | | | | | 10 | 11 | 12 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Stream Number [b] | Small Facility | Medium Facility | Large Facility | Toluene % LEL | ppmV | Temperature °C | (°F) | Small Facility | Medium Facility | Large Facility | Naphtha % LEL | ppmV | Temperature °C | (°F) |
| 1. (Kg/hr) | 14 | 44 | 314 | | | | | 14 | 44 | 314 | | | | |
| 2. (KgVOC/hr)<br>(Kg/hr) | 4.3<br>18 | 14<br>58 | 99<br>417 | | | | | 4.3<br>18 | 14<br>58 | 99<br>417 | | | | |
| 3. (KgVOC/hr) | 0.53 | 1.5 | 10.3 | | | 27 | ( 80) | 0.53 | 1.5 | 10.3 | | | 27 | ( 80) |
| 4. (KgVOC/hr)<br>(Kg/hr) | 0.04<br>14.2 | 0.1<br>47 | 1.0<br>320 | | | | | 0.04<br>14.2 | 0.1<br>47 | 1.0<br>320 | | | | |
| 5. (Nm$^3$/sec) | 0.0002 | 0.0007 | 0.0052 | | | | | 0.0003 | 0.0009 | 0.0068 | | | | |
| 6. (Nm$^3$/sec) | 0.078 | 0.25 | 1.81 | | | 27 | ( 80) | 0.10 | 0.33 | 2.37 | | | 27 | ( 80) |
| 7. KgVOC/hr)<br>(Nm$^3$/sec) | 3.73<br>0.081 | 12.4<br>0.26 | 87.7<br>1.87 | 25 | 3175 | 93 | (200) | 3.73<br>0.11 | 12.4<br>0.34 | 87.7<br>2.45 | 25 | 2025 | 93 | (200) |

[a] Model plant numbers refer to the model plants listed in Table 6-1.

[b] Stream numbers refer to the streams identified in Figure 6-1.

tions. The stream numbers indicated on these tables correspond to those shown in Figure 6-1. The process rates in Tables 6-3 and 6-4 are for the coated web and the resulting gaseous emissions. Streams 1, 2, and 4 represent the weight of the uncoated, wet coated, and dry coated web, respectively. The other streams represent the gas streams and VOC flowrates in and around the oven. The model plant flowrates are used in Section 6.2 to determine the size of the control equipment.

6.1.2.1 Land and Utility Requirements. The land requirements for the large coater can be estimated assuming that the oven is 91.4 meters (300 feet) long with the unwind, coater, and the wind requiring an additional 9.1 meters (30 feet) on either end. This makes the entire unit 110 meters (360 feet) long. The width of the coating machine is approximately 6.1 meters (20 feet) including area for the recirculation fans. Therefore, the total coater machine area is 670 square meters (7,200 square feet). A significant amount of additional area is required for formulation, slitting, packaging, and storage. The coater area requirements for the small and medium size coater will be approximately proportional to the relative size of web width when compared to the large facility. The silicone release coating machines will be smaller than the adhesive coaters because they require smaller ovens.

The utilities for the coaters consist of electricity for motors and natural gas for oven heat. Electric motors are used on the wind roll, unwind roll, coater, recirculation fans, and exhaust fans. In the model plants the ovens are assumed to be heated with direct-fired natural gas furnaces. The heat requirements are larger in the naphtha solvent cases because the naphtha has a lower LEL and thus requires more oven gas throughput. Table 6-5 lists the electricity and natural gas requirements for the model plants.

6.1.2.2 Raw Materials and Products. The raw materials for the coating operations consist of two items: (1) the web and (2) the coating material. For the silicone release coating model plants the web is considered to be an uncoated sheet. For the adhesive coating model plants, the web is assumed to be a silicone release coated sheet.

TABLE 6-5. UTILITY REQUIREMENTS FOR MODEL PLANTS

| Model Plant | line width |  | line speed |  | Solvent | Coating | Electricity |  | Natural gas requirements |  |
|---|---|---|---|---|---|---|---|---|---|---|
|  | m | (inches) | m/sec | (fpm) |  |  | Kilowatts | (hp) | Nm$^3$/sec | (scfm) |
| 1 | 0.61 | (24) | 0.13 | (25) | Toluene | Adhesive | 153 | (205) | 0.0014 | (3.14) |
| 2 | 0.91 | (36) | 0.3 | (53) | Toluene | Adhesive | 230 | (309) | 0.0046 | (10.31) |
| 3 | 1.5 | (60) | 1.2 | (230) | Toluene | Adhesive | 387 | (519) | 0.0354 | (79.37) |
| 4 | 0.61 | (24) | 0.13 | (25) | Naphtha | Adhesive | 155 | (208) | 0.0019 | (4.26) |
| 5 | 0.91 | (36) | 0.3 | (53) | Naphtha | Adhesive | 237 | (318) | 0.0061 | (13.68) |
| 6 | 1.5 | (60) | 1.2 | (230) | Naphtha | Adhesive | 440 | (590) | 0.0465 | (104.25) |
| 7 | 0.61 | (24) | 0.3 | (25) | Toluene | Release | 150 | (201) | 0.0002 | (0.45) |
| 8 | 0.91 | (36) | 0.13 | (53) | Toluene | Release | 219 | (294) | 0.0052 | (1.57) |
| 9 | 1.5 | (60) | 1.2 | (230) | Toluene | Release | 304 | (408) | 0.0052 | (11.66) |
| 10 | 0.61 | (24) | 0.13 | (25) | Naphtha | Release | 150 | (201) | 0.0003 | (0.67) |
| 11 | 0.91 | (36) | 0.3 | (53) | Naphtha | Release | 221 | (296) | 0.0009 | (2.02) |
| 12 | 1.5 | (60) | 1.2 | (230) | Naphtha | Release | 312 | (418) | 0.0068 | (15.25) |

The coatings are assumed to be mixtures of solids and either pure toluene or pure VM&P naphtha solvents. The adhesive formulation is 66.7 weight percent solvent, while the silicone formulation is 95 weight percent solvent.

### 6.1.3 Process Alternatives

Some solvent adhesive and silicone release coatings can be replaced by commercially available nonsolvent formulations. The alternatives are either water emulsion silicone and adhesive coatings or hot melt adhesive coatings and 100 percent solids silicone release coatings. A discussion of these alternatives is given in Chapter 3.

Figures 6-2 and 6-3 show schematic diagrams of waterborne (or 100 percent silicone solids) and hot melt coating operations, respectively. Material balances are estimated for both cases based on the design parameters and production rates used with the solvent coating model plants. Tables 6-6 and 6-7 present the results of the material balances for both the adhesive and silicone release coating operations, respectively. These model plants are used in Chapter 8 as a cost comparison to controlled solvent-type coating operations.

### 6.1.4 Process Modifications or Reconstructions

Process modifications and reconstructions are defined in Chapter 5. There are no model plants in this chapter that specifically represent process modifications or reconstructions. If installations have modifications or reconstructions that result in coming under the NSPS guidelines, they will probably install control devices exactly the same as in new facilities. The only difference comes from added retrofitting costs for longer ducts. However, many new facilities will be under the same constraints as modified or reconstructed facilities because they will be located in the same buildings as existing coating lines. This will mean the capital and operating costs will be nearly identical.

## 6.2 REGULATORY ALTERNATIVES

In this section three control levels are discussed: (1) Alternative I (baseline control), (2) Alternative II (moderate control), and (3) Alternative III (stringent control). In Chapter 4 past and current

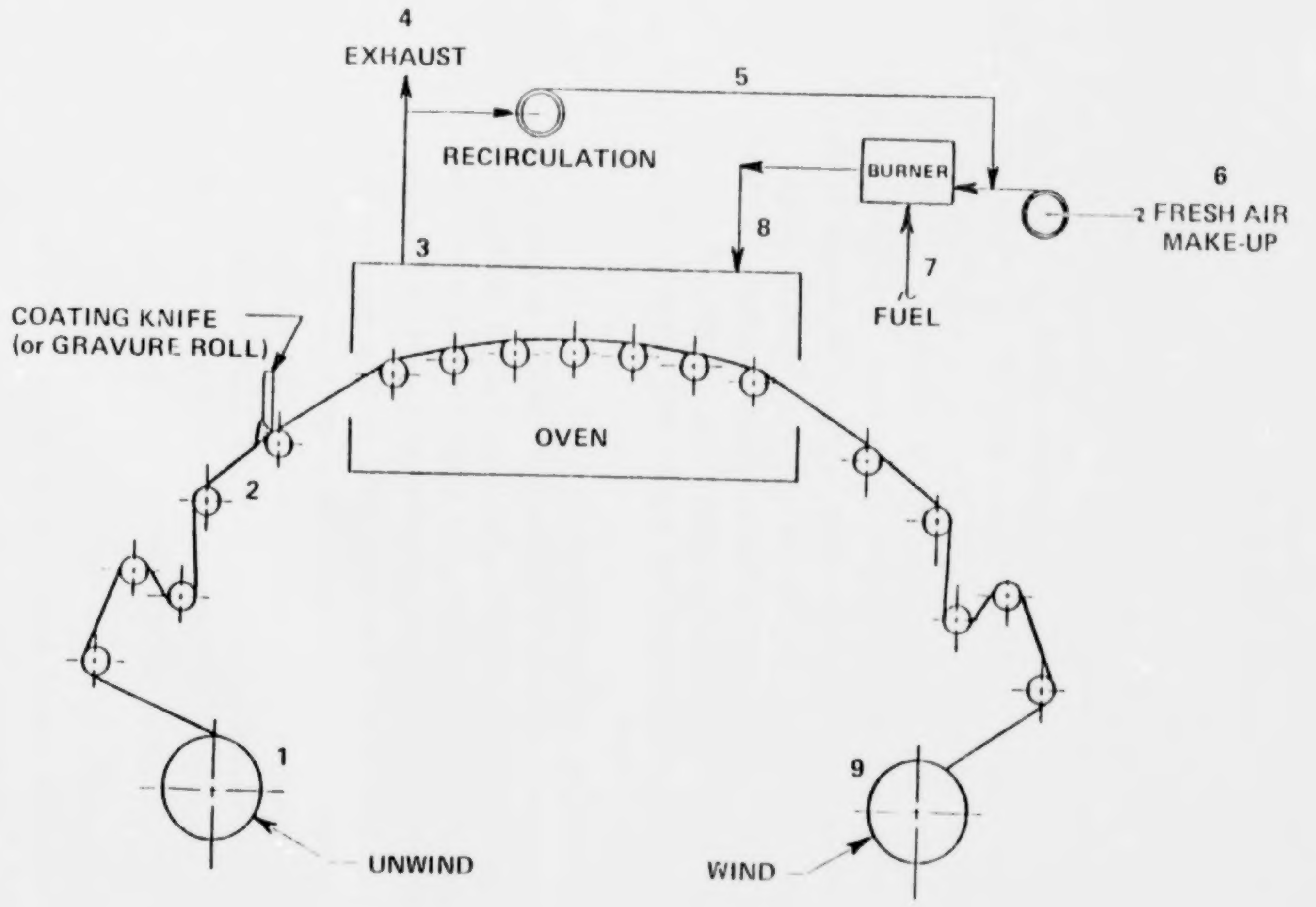
4
EXHAUST
5
RECIRCULATION
BURNER
6
FRESH AIR
MAKE-UP
3
8
7
FUEL
COATING KNIFE
(or GRAVURE ROLL)
OVEN
2
1
9
UNWIND
WIND

Figure 6-2. Schematic diagram of a model coating facility using water-borne (emulsion) coating or 100 percent solid silicone coating.

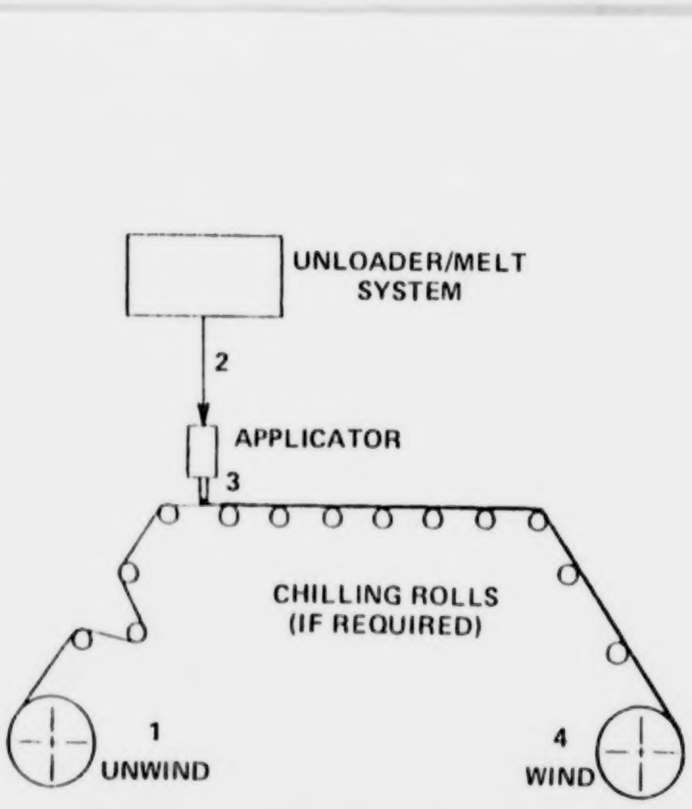
UNLOADER/MELT SYSTEM
2
APPLICATOR
3
CHILLING ROLLS (IF REQUIRED)
1
UNWIND
4
WIND

Figure 6-3. Schematic diagram of a model coating facility using hot melt adhesive coating.

Table 6-6. MODEL PLANT PARAMETERS - ALTERNATE COATING TECHNOLOGIES FOR ADHESIVE COATING LINES

| Stream number[a] | Adhesive waterborne coating | | | | Adhesive hot melt | | | |
|---|---|---|---|---|---|---|---|---|
| | Small facility[b] | Medium facility[c] | Large facility[d] | Temperature °C (°F) | Small facility[b] | Medium facility[c] | Large facility[d] | Temperature °C (°F) |
| 1. (kg/hr) | 14 | 44 | 312 | | 14 | 44 | 314 | 27 (80) |
| 2. (kg/hr) | 42.2 | 135 | 972 | | 14 | 46 | 329 | 163 (325) |
| 3. (kg/hr)<br>(Nm$^3$/sec) | 1800<br>0.42 | 5750<br>1.33 | 41,300<br>9.55 | 104 (220) | 28 | 89 | 643 | 96 (205) |
| 4. (kg/hr)<br>(Nm$^3$/sec) | 110<br>0.03 | 352<br>0.08 | 2530<br>0.59 | 104 (220) | 28 | 89 | 643 | 38 (100) |
| 5. (kg/hr)<br>(Nm$^3$/sec) | 1690<br>0.39 | 5400<br>1.25 | 38,800<br>8.97 | 104 (220) | | | | |
| 6. (kg/hr)<br>(Nm$^3$/sec) | 94.5<br>0.02 | 302<br>0.07 | 2174<br>0.47 | 27 (80) | | | | |
| 7. (kg/hr)<br>(Nm$^3$/sec) | 1.3<br>0.001 | 4.0<br>0.001 | 29<br>0.006 | | | | | |
| 8. (kg/hr)<br>(Nm$^3$/sec) | 1780<br>0.41 | 5700<br>1.3 | 40,990<br>9.44 | 132 (270) | | | | |
| 9. (kg/hr) | 28.3 | 90.4 | 650 | | | | | |

[a] The stream numbers represent the streams in Figure 6-2 for the waterborne coating model plants and Figure 6-3 for the hot melt coating model plants.

[b] Small facility - 0.61m (24") web width and 0.13 m/sec (25 fpm) line speed.

[c] Medium facility - 0.9m (36") web width and 0.3 m/sec (53 fpm) line speed.

[d] Large facility - 1.5m (60") web width and 1.2 m/sec (250 fpm) line speed.

## Table 6-7. MODEL PLANT PARAMETERS - ALTERNATE COATING TECHNOLOGIES FOR SILICONE RELEASE COATING LINES

| | Silicone Release waterborne coating | | | | Silicone release 100 percent solids | | | |
|---|---|---|---|---|---|---|---|---|
| Stream number[a] | Small facility[b] | Medium facility[c] | Large facility[d] | Temperature °C (°F) | Small facility[b] | Medium facility[c] | Large facility[d] | Temperature °C (°F) |
| 1. (kg/hr) | 14 | 44 | 314 | | 14 | 44 | 314 | 27 (80) |
| 2. (kg/hr) | 0.58 | 1.8 | 13 | | 0.23 | 0.72 | 5.2 | |
| 3. (kg/hr)<br>(Nm$^3$/sec) | 247<br>0.053 | 792<br>0.17 | 5770<br>1.24 | 104 (220) | 14.2 | 44.7 | 319 | |
| 4. (kg/hr)<br>(Nm$^3$/sec) | 0.025<br>0.00043 | 0.079<br>0.0014 | 0.58<br>0.0097 | 104 (220) | | | | |
| 5. (kg/hr)<br>(Nm$^3$/sec) | 247<br>0.053 | 792<br>0.17 | 5770<br>1.24 | 104 (220) | | | | |
| 6. (kg/hr)<br>(Nm$^3$/sec) | 0.022<br>0.00036 | 0.069<br>0.0011 | 0.50<br>0.0081 | 27 (80) | | | | |
| 7. (kg/hr)<br>(Nm$^3$/sec) | 0.13<br>0.00005 | 0.42<br>0.00017 | 3.0<br>0.0012 | | 0.13<br>0.00005 | 0.42<br>0.00017 | 3.0<br>0.0012 | |
| 8. (kg/hr)<br>(Nm$^3$/sec) | 247<br>0.053 | 792<br>0.17 | 5770<br>1.24 | 132 (270) | | | | 260 (500) |
| 9. (kg/hr) | 14.2 | 44.7 | 319 | | 14.2 | 44.7 | 319 | |

[a] The stream numbers represent the streams in Figure 6-2 for the waterborne coating model plants and the 100 percent solids coating model plants.

[b] Small facility - 0.61m (24") web width and 0.13 m/sec (25 fpm) line speed.

[c] Medium facility - 0.9m (36") web width and 0.3 m/sec (53 fpm) line speed.

[d] Large facility - 1.5m (60") web width and 1.2 m/sec (250 fpm) line speed.

state and federal regulations are discussed. As mentioned in that chapter, the recommended CTG guidelines are used as the baseline control level. This baseline level represents the level of control that would probably result if the NSPS was not promulgated. The moderate and stringent control cases represent two potential NSPS control levels which will be examined for their environmental, economic, and energy impacts in subsequent chapters.

### 6.2.1 Alternative I Control Requirements

As previously mentioned the Alternative I control level is assumed to be represented by the recommended EPA CTG control levels of 0.35 kilogram VOC per liter of coating (2.9 lbs per gallon of coating) excluding water.[5] For the adhesive model plants the required control level can be calculated based on the physical properties of the adhesive formulation. The adhesive formulation is 66.7 weight percent solvent and 33.3 weight percent solid adhesive. The specific gravity of the formulation is 0.935 and the solvent is 0.863. Applying these numbers to the conversion method described in Appendix D of the EPA Guideline Document[6] the required VOC reduction is approximately 78.3 percent of the total solvent in the coating. This control level is used as the baseline control alternative for comparison of the other adhesive model plants' control alternatives.

A calculation identical to that for adhesive formulations was performed on a typical silicone release formulation to determine the overall VOC reduction necessary to meet the control level of the regulatory alternative. It was determined that a 97 percent overall VOC reduction would be required to achieve Alternative I control. This VOC reduction level was higher than any demonstrated by best available control technology. Consequently, for the silicone release model plants, an Alternative I control level equivalent to that of adhesive plants was assigned. The required VOC reduction for both would be 78.3 percent of the total solvent in the coating.

### 6.2.2 Alternative II Control Requirements

The Alternative II level of control for adhesive and silicone release coating lines is meant to represent the case where only the oven exhaust emissions are controlled on a new coating facility. This means there is no (or very little) attempt to control fugitive VOC emissions around the coater. As mentioned before, there is some indication that there may be a higher relative percentage of fugitive VOC loss in slow coating lines as compared to fast coating lines.[5] The Alternative II control levels for the model plants reflect this assumption. The level of overall VOC emission reduction is estimated at 86 percent for large, fast lines; 85 percent for medium lines; and 84 percent for slower, small lines. All of these levels of control are based on a 96 percent VOC emission reduction across the control device.

### 6.2.3 Alternative III Control Requirements

The Alternative III control level is defined as optimum capture and control of oven exhaust gases and fugitive VOC emissions around the coating area. In both the adhesive and silicone release model plants with carbon adsorbers, it is assumed that the hood exhaust gases are used as makeup air for the oven burners. In the model plants with incinerators, the hood exhaust gases are first ducted to the secondary heat exchanger and again are used as the oven makeup air. Incinerator controls have larger makeup air requirements than carbon adsorber controls. The larger requirement is due to the lower LEL for VM&P naphtha than for toluene solvents. The greater hood gas flow allows for greater VOC capture potential. The estimated Alternative III overall VOC reduction for the model plants is 90 percent. The overall VOC reductions are based on a 96 percent VOC reduction across the control devices.

### 6.2.4 Controlled Model Plant Parameters

When the three control level variations are applied to the twelve uncontrolled model plants, the result is 36 controlled model plant variations or cases. Table 6-8 illustrates all 36 control cases. Figures 6-4 and 6-5 show the model plant configurations for a facility controlled by carbon adsorption and incineration, respectively.

Material balances are calculated for all 36 control cases. The results of these calculations are shown in Tables 6-9 through 6-12. The stream numbers in these tables relate to the stream numbers shown in

Table 6-8. PRESSURE SENSITIVE TAPES AND LABELS MODEL PLANT MATRIX

| Case no. | Model plant no.[a] | Control level[b] | Web width, m (inches) | | | Line speed, m/sec (fpm) | | | Solvent | | Streams controlled | | Type of emission control | | Type of coating | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | 0.61(24) | 0.91(36) | 1.5(60) | 0.13(25) | 0.3(55) | 1.2(230) | Toluene | VM&P naphtha | Oven only | Oven plus fugitives | Carbon adsorption | Incineration | Adhesive | Silicone |
| 1 | 1 | b | x | | | x | | | x | | x | | x | | x | |
| 2 | 1 | m | x | | | x | | | x | | x | | x | | x | |
| 3 | 1 | s | x | | | x | | | x | | | x | x | | x | |
| 4 | 2 | b | | x | | | x | | x | | x | | x | | x | |
| 5 | 2 | m | | x | | | x | | x | | x | | x | | x | |
| 6 | 2 | s | | x | | | x | | x | | | x | x | | x | |
| 7 | 3 | b | | | x | | | x | x | | x | | x | | x | |
| 8 | 3 | m | | | x | | | x | x | | x | | x | | x | |
| 9 | 3 | s | | | x | | | x | x | | | x | x | | x | |
| 10 | 4 | b | x | | | x | | | | x | x | | | x | x | |
| 11 | 4 | m | x | | | x | | | | x | x | | | x | x | |
| 12 | 4 | s | x | | | x | | | | x | | x | | x | x | |
| 13 | 5 | b | | x | | | x | | | x | x | | | x | x | |
| 14 | 5 | m | | x | | | x | | | x | x | | | x | x | |
| 15 | 5 | s | | x | | | x | | | x | | x | | x | x | |
| 16 | 6 | b | | | x | | | x | | x | x | | | x | x | |
| 17 | 6 | m | | | x | | | x | | x | x | | | x | x | |
| 18 | 6 | s | | | x | | | x | | x | | x | | x | x | |
| 19 | 7 | b | x | | | x | | | x | | x | | x | | | x |
| 20 | 7 | m | x | | | x | | | x | | | x | x | | | x |
| 21 | 7 | s | x | | | x | | | x | | | x | x | | | x |
| 22 | 8 | b | | x | | | x | | x | | x | | x | | | x |
| 23 | 8 | m | | x | | | x | | x | | | x | x | | | x |
| 24 | 8 | s | | x | | | x | | x | | | x | x | | | x |
| 25 | 9 | b | | | x | | | x | x | | x | | x | | | x |
| 26 | 9 | m | | | x | | | x | x | | | x | x | | | x |
| 27 | 9 | s | | | x | | | x | x | | | x | x | | | x |
| 28 | 10 | b | x | | | x | | | | x | x | | | x | | x |
| 29 | 10 | m | x | | | x | | | | x | | x | | x | | x |
| 30 | 10 | s | x | | | x | | | | x | | x | | x | | x |
| 31 | 11 | b | | x | | | x | | | x | x | | | x | | x |
| 32 | 11 | m | | x | | | x | | | x | | x | | x | | x |
| 33 | 11 | s | | x | | | x | | | x | | x | | x | | x |
| 34 | 12 | b | | | x | | | x | | x | x | | | x | | x |
| 35 | 12 | m | | | x | | | x | | x | | x | | x | | x |
| 36 | 12 | s | | | x | | | x | | x | | x | | x | | x |

[a] Model plant numbers refer to the 12 model plants discussed in Section 6.1 (see Table 6-1).

[b] b=baseline; m=moderate; s=stringent

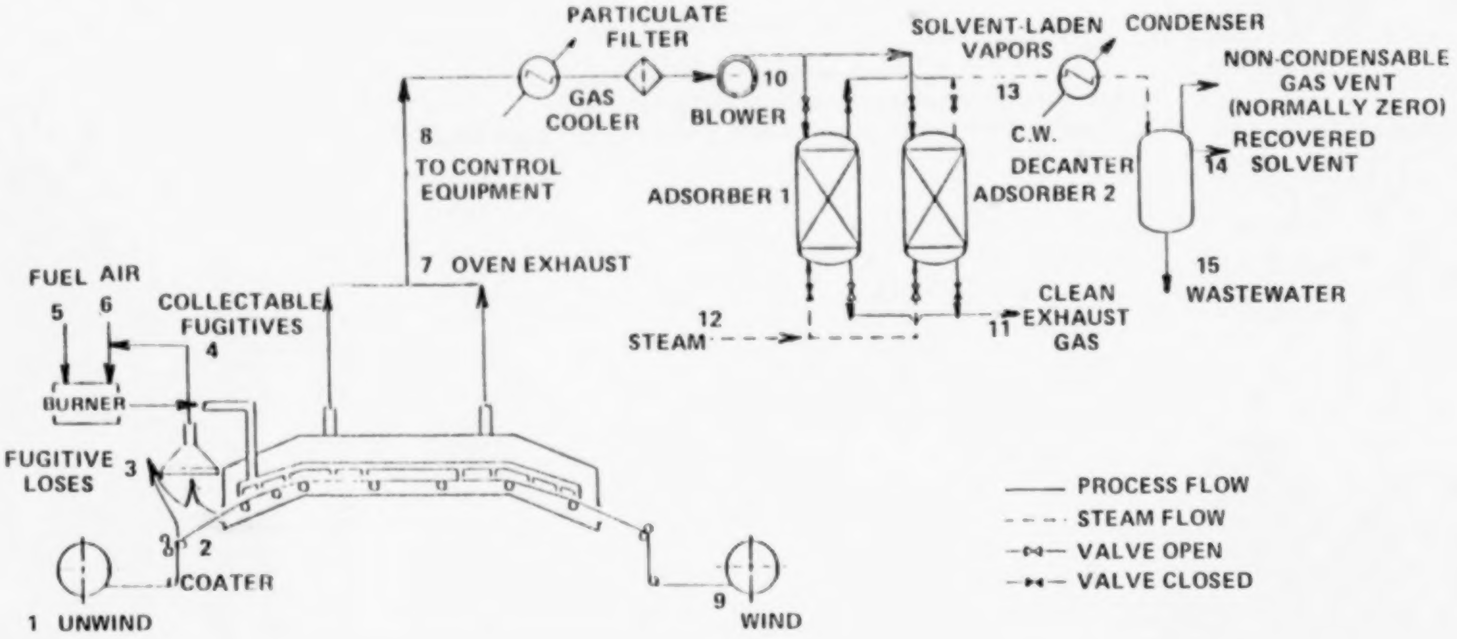
PARTICULATE FILTER
SOLVENT-LADEN VAPORS
CONDENSER
NON-CONDENSABLE GAS VENT (NORMALLY ZERO)
GAS COOLER
10
BLOWER
13
C.W.
RECOVERED SOLVENT
14
8
TO CONTROL EQUIPMENT
DECANTER
ADSORBER 1
ADSORBER 2
7 OVEN EXHAUST
15
WASTEWATER
FUEL AIR
5
6
COLLECTABLE FUGITIVES
4
12
STEAM
11
CLEAN EXHAUST GAS
BURNER
FUGITIVE LOSES
3
2
COATER
1 UNWIND
9
WIND
PROCESS FLOW
STEAM FLOW
VALVE OPEN
VALVE CLOSED

Figure 6-4. Schematic diagram of a model coating facility controlled by carbon adsorption.

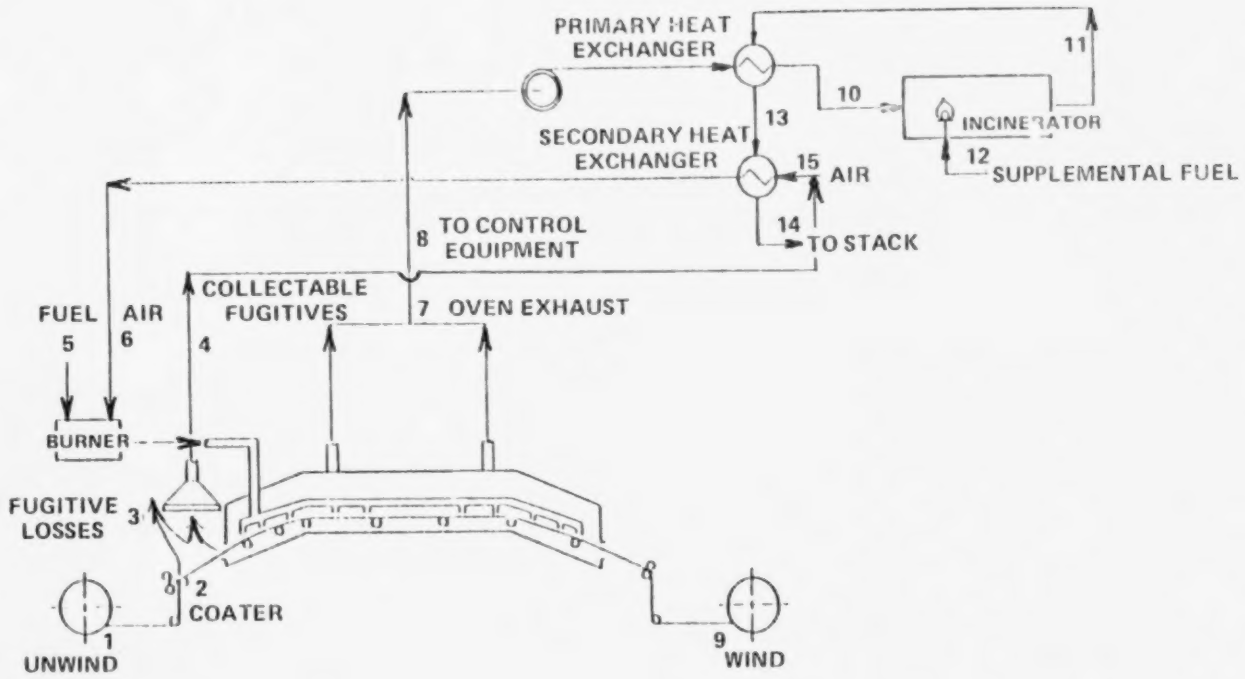
PRIMARY HEAT EXCHANGER
11
10
INCINERATOR
13
SECONDARY HEAT EXCHANGER
15
AIR
12
SUPPLEMENTAL FUEL
8
TO CONTROL EQUIPMENT
14
TO STACK
COLLECTABLE FUGITIVES
7
OVEN EXHAUST
FUEL
5
AIR
6
4
BURNER
FUGITIVE LOSSES
3
2
COATER
1
UNWIND
9
WIND

Figure 6-5. Schematic diagram of a model coating facility controlled by thermal incineration with primary and secondary heat recovery.

TABLE 6-9. MODEL PLANT PARAMETERS - ADHESIVE COATING LINES CONTROLLED BY CARBON ADSORPTION

| Model Plant No. | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Small Facility 0.61m, 0.13m/sec | | | Medium Facility 0.9m, 0.3m/sec | | | Large Facility 1.5m, 1.2m/sec | | | Toluene | | | Temperature | |
| Stream Number [a] | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | % LEL | ppmV | ppmW | °C | (°F) |
| 1. (Kg/hr) | 14 | 14 | 14 | 44 | 44 | 44 | 314 | 314 | 314 | | | | | |
| 2. (KgVOC/hr) | 28.8 | 28.8 | 28.8 | 91 | 91 | 91 | 665 | 665 | 665 | | | | | |
| (kg/hr) | 57 | 57 | 57 | 180 | 180 | 180 | 1308 | 1308 | 1308 | | | | | |
| 3. (KgVOC/hr) | 3.8 | 3.0 | 1.5 | 15.6 | 9.6 | 4.8 | 116 | 60 | 33.4 | | | | 27 | ( 80) |
| 4. (KgVOC/hr) | 0 | 0 | 1.5 | 0 | 0 | 8.1 | 0 | 0 | 26.6 | | | | | |
| ($Nm^3$/sec) | 0 | 0 | 0.34 | 0 | 0 | 0.92 | 0 | 0 | 2.8 | | 200 | | 27 | ( 80) |
| 5. ($Nm^3$/sec) | 0.0015 | 0.0016 | 0.0017 | 0.0048 | 0.0052 | 0.0051 | 0.0348 | 0.0348 | 0.0401 | | | | | |
| 6. ($Nm^3$/sec) | 0.489 | 0.525 | 0.556 | 1.532 | 1.656 | 1.652 | 11.17 | 12.32 | 12.87 | | 0 | | 27 | ( 80) |
| 7. (KgVOC/hr) | 23.7 | 25.5 | 27.0 | 74.4 | 80.4 | 80.2 | 542 | 598 | 625 | | | | | |
| ($Nm^3$/sec) | 0.505 | 0.543 | 0.575 | 1.585 | 1.713 | 1.708 | 11.55 | 12.74 | 13.31 | 25 | 3175 | | 93 | (200) |
| 8. (KgVOC/hr) | 23.7 | 25.5 | 27.0 | 74.4 | 80.4 | 80.2 | 542 | 598 | 625 | | | | | |
| ($Nm^3$/sec) | 0.505 | 0.543 | 0.575 | 1.585 | 1.713 | 1.708 | 11.55 | 12.74 | 13.31 | 25 | 3175 | | 93 | (200) |
| 9. (KgVOC/hr) | 0.3 | 0.3 | 0.3 | 1.0 | 1.0 | 1.0 | 6.7 | 6.7 | 6.7 | | | | | |
| (Kg/hr) | 28 | 28 | 28 | 89 | 89 | 89 | 650 | 650 | 650 | | | | | |
| 10. (KgVOC/hr) | 23.7 | 25.5 | 27.0 | 74.4 | 80.4 | 80.2 | 542 | 598 | 625 | 25 | 3175 | | | |
| ($Nm^3$/sec) | 0.505 | 0.543 | 0.575 | 1.575 | 1.713 | 1.708 | 11.55 | 12.74 | 13.31 | | | | 38 | (100) |
| 11. (KgVOC/hr) | 0.948 | 1.020 | 1.080 | 2.98 | 3.22 | 3.21 | 21.7 | 23.9 | 25.0 | | 200 | | | |
| ($Nm^3$/sec) | 0.505 | 0.543 | 0.575 | 1.585 | 1.713 | 1.708 | 11.55 | 12.74 | 13.31 | | | | 38 | (100) |
| 12. (Kg/hr) | 91.01 | 97.9 | 103.7 | 286 | 309 | 308 | 2081 | 2296 | 2400 | | | | 132 | (270) |
| 13. (KgVOC/hr) | 22.75 | 24.5 | 25.9 | 71.4 | 77.2 | 77.0 | 520 | 574 | 600 | | | | 121 | (250) |
| 14. (KgVOC/hr) | 22.7 | 24.45 | 25.5 | 71.3 | 77.0 | 76.8 | 519 | 573 | 599 | | | | 38 | (100) |
| 15. (KgVOC/hr) | 0.0455 | 0.0490 | 0.0518 | 0.1428 | 0.1544 | 0.1540 | 1.041 | 1.148 | 1.200 | | | 500 | | |
| (kg/hr) | 91.1 | 98.9 | 103.8 | 286.1 | 309.2 | 308.2 | 2082 | 2297 | 2401 | | | | 38 | (100) |

[a] Stream numbers represent the streams shown in Figure 6-4.

## TABLE 6-10. MODEL PLANT PARAMETERS - ADHESIVE COATING LINES CONTROLLED BY INCINERATION

| Model Plant No. | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Small Facility 0.61m, 0.13m/sec | | | Medium Facility 0.9m, 0.3m/sec | | | Large Facility 1.5m, 1.2m/sec | | | Naphtha | | Temperature | |
| Stream Number [a] | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | % LEL | ppmV | $^oC$ | ($^oF$) |
| 1. (Kg/hr) | 14 | 14 | 14 | 44 | 44 | 44 | 314 | 314 | 314 | | | | |
| 2. (KgVOC/hr) | 28.8 | 28.8 | 28.8 | 91 | 91 | 91 | 664 | 664 | 664 | | | | |
| (Kg/hr) | 57 | 57 | 57 | 180 | 180 | 180 | 1308 | 1308 | 1308 | | | | |
| 3. (KgVOC/hr) | 5.0 | 3.0 | 1.5 | 15.8 | 10.9 | 6.1 | 115 | 70 | 34 | | | 27 | (180) |
| 4. (KgVOC/hr) | 0 | 0 | 1.5 | 0 | 0 | 4.8 | 0 | 0 | 24 | | | | |
| ($Nm^3$/sec) | 0 | 0 | 0.37 | 0 | 0 | 1.2 | 0 | 0 | 6.8 | | 200[b] | 27 | ( 80) |
| 5. ($Nm^3$/sec) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 6. (KgVOC/hr) | 0 | 0 | 1.5 | 0 | 0 | 4.8 | 0 | 0 | 24 | | | | |
| ($Nm^3$/sec) | 0.656 | 0.712 | 0.754 | 2.073 | 2.182 | 2.21 | 15.14 | 16.40 | 17.40 | | | 110 | (230) |
| 7. (KgVOC/hr) | 23.5 | 25.5 | 27.0 | 74.2 | 78.1 | 79.1 | 542 | 587 | 623 | | | | |
| ($Nm^3$/sec) | 0.656 | 0.712 | 0.754 | 2.073 | 2.182 | 2.21 | 15.14 | 16.40 | 17.40 | 25 | 2025 | 93 | (200) |
| 8. (KgVOC/hr) | 23.5 | 25.5 | 27.0 | 74.2 | 78.1 | 79.1 | 542 | 587 | 623 | | | | |
| ($Nm^3$/sec) | 0.656 | 0.712 | 0.754 | 2.073 | 2.182 | 2.21 | 15.14 | 16.40 | 17.40 | 25 | 2025 | 93 | (200) |
| 9. (KgVOC/hr) | 0.3 | 0.3 | 0.3 | 1.0 | 1.0 | 1.0 | 6.7 | 6.7 | 6.7 | | | | |
| (Kg/hr) | 28 | 28 | 28 | 89 | 89 | 89 | 650 | 650 | 650 | | | | |
| 10. (KgVOC/hr) | 23.5 | 25.5 | 27.0 | 74.2 | 78.1 | 79.1 | 542 | 587 | 623 | | | | |
| ($Nm^3$/sec) | 0.656 | 0.712 | 0.754 | 2.073 | 2.182 | 2.21 | 15.14 | 16.40 | 17.40 | 25 | 2025 | 253 | (488) |
| 11. (KgVOC/hr) | 0.94 | 1.02 | 1.08 | 2.97 | 3.1 | 3.1 | 21.7 | 23.5 | 24.9 | | | | |
| ($Nm^3$/sec) | 0.711 | 0.772 | 0.817 | 2.25 | 2.36 | 2.39 | 16.40 | 17.76 | 18.85 | | 80.5 | 760 | (1400) |
| 12. ($Nm^3$/sec) | 0.0046 | 0.0050 | 0.0053 | 0.0146 | 0.0154 | 0.0156 | 0.1068 | 0.1155 | 0.1225 | | | | |
| 13. (KgVOC/hr) | 0.94 | 1.02 | 1.08 | 2.97 | 3.1 | 3.1 | 21.7 | 23.5 | 24.9 | | | | |
| ($Nm^3$/sec) | 0.711 | 0.772 | 0.817 | 2.25 | 2.36 | 2.39 | 16.40 | 17.76 | 18.85 | | | 623 | (1153) |
| 14. (KgVOC/hr)<br>($Nm^3$/sec) | 0.94<br>0.711 | 1.02<br>0.772 | 1.08<br>0.817 | 2.97<br>2.25 | 3.1<br>2.36 | 3.1<br>2.39 | 21.7<br>16.40 | 23.5<br>17.76 | 24.9<br>18.85 | | | 546 | (1015) |
| 15. (KgVOC/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| ($Nm^3$/sec) | 0.656 | 0.712 | 0.384 | 2.073 | 2.182 | 1.01 | 15.14 | 16.40 | 10.6 | | | 27 | ( [illegible]) |

[a] Stream numbers represent the streams shown in Figure 6-5.

[b] Only for stringent cases.

[c] Incinerators require 0.57 $Nm^3$/hr of natural gas for pilot flame.

## TABLE 6-11. MODEL PLANT PARAMETERS - SILICONE RELEASE COATING LINES CONTROLLED BY CARBON ADSORPTION

| Model Plant No. | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Small Facility 0.61m, 0.13m/sec | | | Medium Facility 0.9m, 0.3m/sec | | | Large Facility 1.5m, 1.2m/sec | | | Toluene | | Temperature | |
| Stream Number [a] | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | % LEL | ppmV | $^oC$ | $(^oF)$ |
| 1. (Kg/hr) | 14 | 14 | 14 | 44 | 44 | 44 | 314 | 314 | 314 | | | | |
| 2. (KgVOC/hr) | 4.3 | 4.3 | 4.3 | 14 | 14 | 14 | 99 | 99 | 99 | | | | |
| (Kg/hr) | 18 | 18 | 18 | 58 | 58 | 58 | 417 | 417 | 417 | | | | |
| 3. (KgVOC/hr) | 0.53 | 0.45 | 0.05 | 2.4 | 1.5 | 0.76 | 17.3 | 10.3 | 5.2 | | | | |
| 4. (KgVOC/hr) | 0 | 0 | 0.30 | 0 | 0 | 0.74 | 0 | 0 | 5.1 | | Var[b] | 27 | ( 80) |
| ($Nm^3$/sec) | 0 | 0 | 0.53 | 0 | 0 | 0.17 | 0 | 0 | 1.23 | | | | |
| 5. ($Nm^3$/sec) | 0.0002 | 0.0002 | 0.0003 | 0.0007 | 0.0008 | 0.0008 | 0.0052 | 0.0056 | 0.0060 | | | | |
| 6. ($Nm^3$/sec) | 0.0732 | 0.0787 | 0.0819 | 0.237 | 0.249 | 0.264 | 1.662 | 1.806 | 1.911 | | 0 | 27 | ( 80) |
| 7. (KgVOC/hr) | 3.54 | 3.8 | 4.0 | 11.5 | 12.1 | 12.8 | 80.7 | 87.7 | 92.8 | | | | |
| ($Nm^3$/sec) | 0.0754 | 0.0809 | 0.0852 | 0.245 | 0.258 | 0.273 | 1.719 | 1.868 | 1.977 | 25 | 3175 | 93 | (200) |
| 8. (KgVOC/hr) | 3.54 | 3.8 | 4.0 | 11.5 | 12.1 | 12.8 | 80.7 | 87.7 | 92.8 | | | | |
| ($Nm^3$/sec) | 0.0754 | 0.0809 | 0.0852 | 0.245 | 0.258 | 0.273 | 1.719 | 1.868 | 1.977 | 25 | 3175 | 93 | (200) |
| 9. (KgVOC/hr) | 0.04 | 0.04 | 0.04 | 0.1 | 0.1 | 0.1 | 1.0 | 1.0 | 1.0 | | | | |
| (kg/hr) | 14.2 | 14.2 | 14.2 | 47 | 47 | 47 | 320 | 320 | 320 | | | | |
| 10. (KgVOC/hr) | 3.54 | 3.8 | 4.0 | 11.5 | 12.1 | 12.8 | 80.7 | 87.7 | 92.8 | | | | |
| ($Nm^3$/sec) | 0.0754 | 0.0809 | 0.0852 | 0.245 | 0.258 | 0.273 | 1.719 | 1.868 | 1.977 | 25 | 3175 | 93 | (200) |
| 11. (KgVOC/hr) | 0.1416 | 0.1520 | 0.1600 | 0.460 | 0.484 | 0.512 | 3.23 | 3.51 | 3.71 | | | | |
| ($Nm^3$/sec) | 0.0754 | 0.0809 | 0.0852 | 0.245 | 0.258 | 0.273 | 1.719 | 1.868 | 1.977 | | 200 | 38 | (100) |
| 12. (Kg/hr) | 13.59 | 14.59 | 15.36 | 44.2 | 46.5 | 49.2 | 310 | 337 | 356 | | | 132 | (270) |
| 13. (KgVOC/hr) | 3.40 | 3.65 | 3.84 | 11.04 | 11.62 | 12.29 | 77.5 | 84.2 | 89.1 | | | 121 | (250) |
| 14. (KgVOC/hr) | 3.39 | 3.64 | 3.83 | 11.02 | 11.6 | 12.3 | 77.3 | 84.0 | 88.9 | | | 38 | (100) |
| 15. (KgVOC/hr) | 0.0068 | 0.0073 | 0.0077 | 0.0221 | 0.0232 | 0.0246 | 0.1549 | 0.1684 | 0.1782 | | | | |
| (Kg/hr) | 13.6 | 14.6 | 15.4 | 44.2 | 46.5 | 49.2 | 310.2 | 337.2 | 356.2 | | | 38 | (100) |

[a] Stream numbers represent the streams shown in Figure 6-4.

[b] VAR - Variable, can be calculated based on the gas flow rate and the VOC flow rate.

TABLE 6-12. MODEL PLANT PARAMETERS - SILICONE RELEASE COATING LINE CONTROLLED BY INCINERATION

| Model Plant No. | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Small Facility 0.61m, 0.13m/sec | | | Medium Facility 0.9m, 0.3m/sec | | | Large Facility 1.5m, 1.2m/sec | | | Naphtha | | Temperature | |
| Stream Number [a] | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | Baseline Control | Moderate Control | Stringent Control | % LEL | ppmV | °C | (°F) |
| 1. (Kg/hr) | 14 | 14 | 14 | 44 | 44 | 44 | 314 | 314 | 314 | | | | |
| 2. (KgVOC/hr) | 4.3 | 4.3 | 4.3 | 14 | 14 | 14 | 99 | 99 | 99 | | | | |
| (Kg/hr) | 18 | 18 | 18 | 58 | 58 | 58 | 417 | 417 | 417 | | | | |
| 3. (KgVOC/hr) | 0.72 | 0.45 | 0.23 | 2.4 | 1.5 | 0.76 | 17.3 | 10.3 | 5.2 | | | 27 | ( 80) |
| 4. (KgVOC/hr) | 0 | 0 | 0.30 | 0 | 0 | 0.74 | 0 | 0 | 5.1 | | | | |
| (Nm$^3$/sec) | 0 | 0 | 0.084 | 0 | 0 | 0.21 | 0 | 0 | 1.44 | | Var[b] | 27 | ( 80) |
| 5. (Nm$^3$/sec) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| 6. (KgVOC/hr) | 0 | 0 | 0.30 | 0 | 0 | 0.74 | 0 | 0 | 5.1 | | | | |
| (Nm$^3$/sec) | 0.0989 | 0.1064 | 0.1117 | 0.321 | 0.338 | 0.358 | 2.25 | 2.45 | 2.59 | | | 110 | (230) |
| 7. (KgVOC/hr) | 3.5 | 3.8 | 4.0 | 11.5 | 12.1 | 12.8 | 80.7 | 87.7 | 92.8 | | | | |
| (Nm$^3$/sec) | 0.0989 | 0.1064 | 0.1117 | 0.321 | 0.338 | 0.358 | 2.25 | 2.45 | 2.59 | 25 | 2025 | 93 | (200) |
| 8. (KgVOC/hr) | 3.5 | 3.8 | 4.0 | 11.5 | 12.1 | 12.8 | 80.7 | 87.7 | 92.8 | | | | |
| (Nm$^3$/sec) | 0.0989 | 0.1064 | 0.1117 | 0.321 | 0.338 | 0.358 | 2.25 | 2.45 | 2.59 | 25 | 205 | 93 | (200) |
| 9. (KgVOC/hr) | 0.04 | 0.04 | 0.04 | 0.1 | 0.1 | 0.1 | 1.0 | 1.0 | 1.0 | | | | |
| (Kg/hr) | 14.2 | 14.2 | 14.2 | 47 | 47 | 47 | 320 | 320 | 320 | | | | |
| 10. (KgVOC/hr) | 3.5 | 3.8 | 4.0 | 11.5 | 12.1 | 12.8 | 80.7 | 87.7 | 92.8 | | | | |
| (Nm$^3$/sec) | 0.0989 | 0.1064 | 0.1117 | 0.321 | 0.338 | 0.358 | 2.25 | 2.45 | 2.59 | 25 | 2025 | 253 | (488) |
| 11. (KgVOC/hr) | 0.14 | 0.2 | 0.2 | 0.5 | 0.5 | 0.5 | 3.2 | 3.5 | 3.7 | | | | |
| (Nm$^3$/sec) | 0.1072 | 0.1153 | 0.1211 | 0.348 | 0.366 | 0.388 | 2.45 | 2.65 | 2.81 | | 80.5 | 760 | (1400) |
| 12. (Nm$^3$/sec) | 0.0007 | 0.0007 | 0.0008 | 0.0023 | 0.0024 | 0.0025 | 0.0159 | 0.0172 | 0.0183 | | | | |
| 13. (KgVOC/hr) | 0.14 | 0.2 | 0.2 | 0.5 | 0.5 | 0.5 | 3.2 | 3.5 | 3.7 | | | | |
| (Nm$^3$/sec) | 0.1072 | 0.1153 | 0.1211 | 0.348 | 0.366 | 0.388 | 2.45 | 2.65 | 2.81 | | 80 | 623 | (1153) |
| 14. (KgVOC/hr) | 0.14 | 0.2 | 0.2 | 0.5 | 0.5 | 0.5 | 3.2 | 3.5 | 3.7 | | | | |
| (Nm$^3$/sec) | 0.1072 | 0.1153 | 0.1211 | 0.348 | 0.366 | 0.388 | 2.45 | 2.65 | 2.81 | | 80 | 546 | (1015) |
| 15. (KgVOC/hr) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | | | |
| (Nm$^3$/sec) | 0.0989 | 0.1064 | 0.0277 | 0.321 | 0.338 | 0.148 | 2.25 | 2.45 | 1.15 | | | 27 | ( 80) |

[a] Stream numbers represent the stream shown in Figure 6-5.

[b] Var - Variable, can be calculated based on the gas flow rate and the VOC flow rate.

Figures 6-4 and 6-5. The control case numbers relate to the controlled model plants listed in Table 6-8. The calculations assume that the control device is 96 percent efficient in recovering or destroying VOC emissions. The 96 percent control level is based on the performance of existing control systems.[11,12,13,14]

The carbon adsorption systems are assumed to consist of three vertical beds in all cases. One bed is used for adsorption, one for regeneration, and one for cool down. The bed depth is approximately 1.2 meters (4 feet) with a pressure drop of 6 kPa (24 inches of water). The unit is constructed of carbon steel. The activated carbon is assumed to be changed every two years for the adhesive cases and every year for the silicone cases.[15] The steam requirements are estimated based on four kilograms of steam per kilogram of recovered solvent (4 lbs steam/lb solvent recovered). The major electricity user is the adsorber fan.

The incinerators are designed with primary and secondary heat recovery. At 25 percent LEL, the combustion of the oven off gas will not supply all the heat energy required for the drying and curing ovens. A fuel energy requirement of from 0.7 to 66 $Nm^3$/hr of natural gas exists. Once again the major electricity user is the incinerator fan.

Table 6-13 lists all the utility requirements and estimated land requirements for the 36 model plant control systems.

The process flow rates and utility requirements shown in Tables 6-9 through 6-13 are used in later sections to estimate the environmental, economic and energy impacts of the three control alternatives.

## TABLE 6-13. UTILITY AND LAND REQUIREMENTS FOR MODEL PLANT CONTROL SYSTEMS

| Case number[a] | No. 2 fuel oil liters/sec(gpm) | Natural Gas Nm³/hr(scfh) | Makeup water liters/sec (gpm) | Electricity kilowatts (hp) | Cooling water liters/sec (gpm) | Replacement carbon MT (tons) | Land requirements[b] m²(ft²) |
|---|---|---|---|---|---|---|---|
| 1 | .0018 (.028) | 5.4 (191) | 0.00253 (0.0401) | 153.6 (206) | 1.71 (27.1) | 1.02 (1.12) | 460 (5000) |
| 2 | .0019 (.031) | 5.8 (203) | 0.00272 (0.0431) | 153.6 (206) | 1.84 (29.1) | 1.09 (1.20) | 460 (5000) |
| 3 | .0020 (.032) | 6.1 (216) | 0.00288 (0.0457) | 153.6 (206) | 1.94 (30.8) | 1.16 (1.27) | 460 (5000) |
| 4 | .0056 (.089) | 17.3 (610) | 0.00794 (0.126) | 233.7 (313) | 5.36 (84.9) | 31.9 (3.51) | 1400 (15,000) |
| 5 | .0061 (.096) | 18.7 (661) | 0.00858 (0.136) | 233.7 (313) | 5.79 (91.8) | 3.45 (3.79) | 1400 (15,000) |
| 6 | .0061 (.096) | 18.4 (648) | 0.00855 (0.136) | 233.7 (313) | 5.78 (91.5) | 3.44 (3.78) | 1400 (15,000) |
| 7 | .0410 (.650) | 125 (4420) | 0.0578 (0.916) | 377.7 (507) | 39.0 (619) | 23.2 (25.6) | 4600 (50,000) |
| 8 | .0452 (.717) | 138 (4880) | 0.0638 (1.01) | 386.5 (518) | 43.1 (683) | 25.6 (28.2) | 4600 (50,000) |
| 9 | .0473 (.750) | 144 (5100) | 0.0667 (1.06) | 391.2 (525) | 45.0 (713) | 26.8 (29.5) | 4600 (50,000) |
| 10 | - | 16.6 (585) | - | 157.3 (211) | - | - | 460 (5000) |
| 11 | - | 18.0 (636) | - | 157.3 (211) | - | - | 460 (5000) |
| 12 | - | 19.1 (674) | - | 157.3 (211) | - | - | 460 (5000) |
| 13 | - | 52.6 (1860) | - | 237.3 (318) | - | - | 1400 (15,000) |
| 14 | - | 55.4 (1960) | - | 237.3 (318) | - | - | 1400 (15,000) |
| 15 | - | 56.2 (1980) | - | 237.3 (318) | - | - | 1400 (15,000) |
| 16 | - | 384 (13600) | - | 404.8 (543) | - | - | 4600 (50,000) |
| 17 | - | 416 (14700) | - | 416.8 (559) | - | - | 4600 (50,000) |
| 18 | - | 441 (15600) | - | 422.2 (566) | - | - | 4600 (50,000) |
| 19 | .0003 (.004) | .7 (25.4) | 0.00038 (0.0060) | 149.5 (200) | .255 (4.04) | .30 (.33) | 46 (500) |
| 20 | .0003 (.004) | .7 (25.4) | 0.00039 (0.0062) | 149.5 (200) | .263 (4.17) | .31 (.34) | 46 (500) |
| 21 | .0003 (.005) | 1.1 (38.1) | 0.00043 (0.0068) | 149.5 (200) | .288 (4.57) | .34 (.38) | 46 (500) |
| 22 | .0009 (.014) | 2.5 (88.0) | 0.00123 (0.0194) | 218.4 (293) | .828 (13.1) | .99 (1.08) | 280 (3000) |
| 23 | .0009 (.015) | 2.9 (102) | 0.00129 (0.0205) | 218.4 (293) | .871 (13.8) | 1.04 (1.14) | 280 (3000) |
| 24 | .0010 (.015) | 2.9 (102) | 0.00137 (0.0216) | 218.4 (293) | .922 (14.6) | 1.10 (1.21) | 280 (3000) |
| 25 | .0061 (.097) | 18.7 (661) | 0.00861 (0.136) | 305.8 (410) | 5.81 (92.1) | 6.92 (7.61) | 1900 (20,000) |
| 26 | .0066 (.105) | 20.2 (712) | 0.00935 (0.140) | 305.8 (410) | 6.32 (100) | 7.52 (8.27) | 1900 (20,000) |
| 27 | .0070 (.111) | 21.6 (763) | 0.00990 (0.157) | 305.8 (410) | 6.68 (106) | 7.95 (8.75) | 1900 (20,000) |
| 28 | - | 2.5 (89) | - | 149.5 (200) | - | - | 46 (500) |
| 29 | - | 2.5 (89) | - | 149.5 (200) | - | - | 46 (500) |
| 30 | - | 2.9 (102) | - | 149.5 (200) | - | - | 46 (500) |
| 31 | - | 8.3 (292) | - | 218.4 (293) | - | - | 280 (3000) |
| 32 | - | 8.6 (305) | - | 218.4 (293) | - | - | 280 (3000) |
| 33 | - | 9.0 (318) | - | 218.4 (293) | - | - | 280 (3000) |
| 34 | - | 57.2 (2020) | - | 309.5 (415) | - | - | 1900 (20,000) |
| 35 | - | 61.9 (2190) | - | 309.5 (415) | - | - | 1900 (20,000) |
| 36 | - | 65.9 (2330) | - | 309.5 (415) | - | - | 1900 (20,000) |

[a] Case numbers represent the cases outlined in Table 6-8.

[b] Land area for adsorbers and incinerators only, does not include other equipment such as boiler or cooling tower.

## 6.3 REFERENCES

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# 7. ENVIRONMENTAL AND ENERGY IMPACTS

The major environmental problem in the pressure sensitive tape and label (PSTL) industry is the emission of large volumes of organic solvents. Presently, over 80 percent of all PSTL products are coated with solvent-based adhesive or release materials.[1] However, in the next ten years a dramatic decrease in the use of organic solvents is expected. Figure 7-1 illustrates the predicted decline of solvent use in the pressure sensitive adhesive (PSA) industry.[2,3] This prediction assumes an average 10 percent annual increase in PSA use.

Even though there is a predicted dramatic decrease in solvent use, there is a definite possibility of new solvent-based coating facilities being installed over the next ten years. This is especially true in the next few years when hot melt and waterborne technology will not be able to match the quality of some solvent-based adhesives and releases. In the absence of regulations, operators would tend to build more solvent-based coating lines, even in the face of increasing solvent costs. The promulgation of a regulation would put more force on operators to convert to low-solvent or solventless technology.

In this chapter the air, water and solid waste pollution impacts are examined for the regulatory alternatives described in Chapter 6. These impacts are examined for individual plants and for the U.S. as a whole. The three regulatory alternatives can be summarized as follows:

- Regulatory Alternative I (Baseline Control) - The VOC control level expected if no NSPS regulations are adopted. The control level represents the recommended CTG control level.
- Regulatory Alternative II (Moderate Control) - This represents the first NSPS control choice of attempting to control oven VOC emissions only.

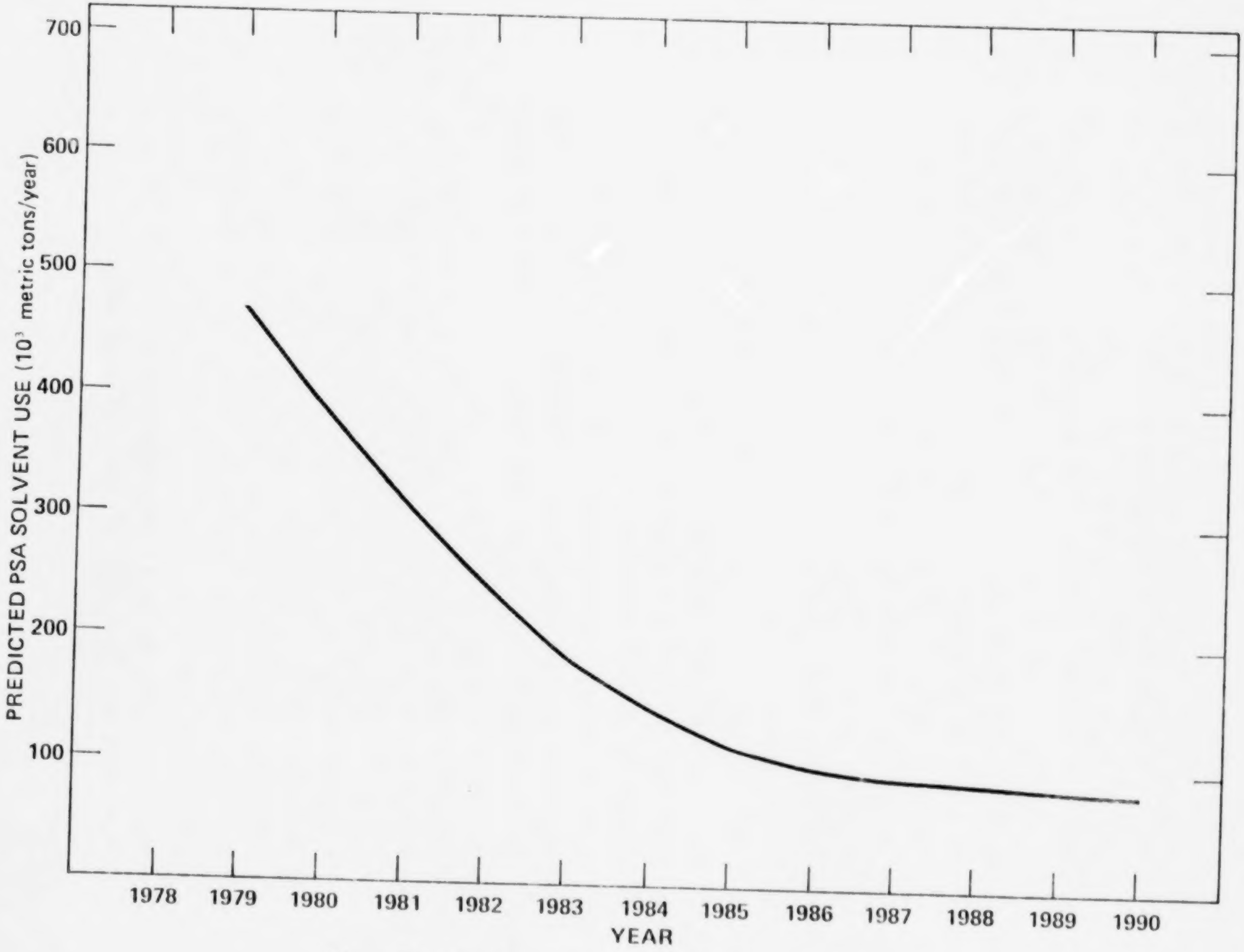

Figure 7-1. Predicted trend of solvent-based coating technologies.

- Regulatory Alternative III (Stringent Control) - This represents the second NSPS control choice of attempting to control oven and fugitive VOC emissions

The model plants are used as the basis of comparison for all of the environmental and energy impacts.

## 7.1 AIR POLLUTION IMPACT

As previously mentioned, the primary adverse impact of solvent-based pressure sensitive adhesive, release, and precoat coating operations is volatile organic compound (VOC) emissions. In uncontrolled facilities, these emissions are emitted directly from the drying ovens and as fugitive emissions from around the coating areas. VOC emissions can be controlled by the addition of control equipment such as incinerators, carbon adsorbers, and hooding systems. Tables 7-1 and 7-2 give the calculated controlled and uncontrolled VOC emissions for the model plants.

### 7.1.1 Primary Air Pollution Impacts

The primary impacts of overall VOC reductions are dependent on the facility location. For the majority of the facilities in heavily industrialized areas, the primary impact is the reduced potential of ambient hydrocarbon levels and thus a reduction in ozone formation. This will also result in a reduction in hydrocarbon aerosol formation. The transformation of hydrocarbons to aerosols involves reactions between the hydrocarbons, ozone, and nitrogen oxides ($NO_x$). The hydrocarbons react to produce oxygenated compounds which form aerosols by either nucleation or condensation.[4] The nitrogen oxide levels required for smog formation are generally only encountered in industrial or urban areas. The majority of PSTL coating operations are located in urban areas.

For plants in rural areas or areas of low ambient nitrogen oxide and ozone concentrations, the primary environmental impact is merely a reduction in overall ambient hydrocarbon levels. However, hydrocarbons from these areas can be transported in the atmosphere to locations where ozone and smog are problems. Hydrocarbon reductions will help reduce these impacts.

## TABLE 7-1. CONTROLLED AND UNCONTROLLED VOC EMISSIONS FROM MODEL PLANTS EMPLOYING CARBON ADSORPTION CONTROLS*

| Facility Size (line size, line speed) Control Levels | Adhesive Coating Model Plants | | | | Silicone Release Coating Model Plants | | | |
|---|---|---|---|---|---|---|---|---|
| | Uncontrolled Emissions | | Controlled Emissions | | Uncontrolled Emissions | | Controlled Emissions | |
| | MT/yr | (Kg VOC/hr) | MT/yr | (Kg VOC/hr) | MT/yr | (Kg VOC/hr) | MT/yr | (Kg VOC/hr) |
| Large (1.5m, 1.2m/sec) | | | | | | | | |
| Alternative I | 3948 | (658) | 828 | (138) | 588 | (98) | 123 | (20.5) |
| Alternative II | 3948 | (658) | 504 | (84) | 588 | (98) | 83 | (13.8) |
| Alternative III | 3948 | (658) | 348 | (58) | 588 | (98) | 53 | ( 8.9) |
| Medium (0.9m, 0.3m/sec) | | | | | | | | |
| Alternative I | 540 | (90) | 113 | (19) | 84 | (14) | 17.4 | ( 2.9) |
| Alternative II | 540 | (90) | 78 | (13) | 84 | (14) | 12 | ( 2.0) |
| Alternative III | 540 | (90) | 48 | ( 8.0) | 84 | (14) | 7.8 | ( 1.3) |
| Small (0.6m, 0.13m/sec) | | | | | | | | |
| Alternative I | 174 | (29) | 28 | ( 4.7) | 26 | (4.3) | 4.0 | ( 0.67) |
| Alternative II | 174 | (29) | 24 | ( 4.0) | 26 | (4.3) | 3.6 | ( 0.60) |
| Alternative III | 174 | (29) | 16 | ( 2.6) | 26 | (4.3) | 1.3 | ( 0.21) |

*Figures represent emissions from a single coating line.

### TABLE 7-2. CONTROLLED AND UNCONTROLLED VOC EMISSIONS FROM MODEL PLANTS EMPLOYING THERMAL INCINERATION CONTROLS*

| Facility Size (line size, line speed) Control Levels | Adhesive Coating Model Plants | | | | Silicone Release Coating Model Plants | | | |
|---|---|---|---|---|---|---|---|---|
| | Uncontrolled Emissions | | Controlled Emissions | | Uncontrolled Emissions | | Controlled Emissions | |
| | MT/yr | (Kg VOC/hr) | MT/yr | (Kg VOC/hr) | MT/yr | (Kg VOC/hr) | MT/yr | (Kg VOC/hr) |
| Large (1.5m, 1.2m/sec) | | | | | | | | |
| Alternative I | 3942 | (657) | 822 | (137) | 588 | (98) | 126 | (21) |
| Alternative II | 3942 | (657) | 564 | ( 94) | 588 | (98) | 84 | (14) |
| Alternative III | 3942 | (657) | 354 | ( 59) | 588 | (98) | 53 | ( 8.9) |
| Medium (0.9m, 0.3m/sec) | | | | | | | | |
| Alternative I | 540 | ( 90) | 114 | ( 19) | 84 | (14) | 17 | ( 2.9) |
| Alternative II | 540 | ( 90) | 84 | ( 14) | 84 | (14) | 12 | ( 2.0) |
| Alternative III | 540 | ( 90) | 55 | ( 9.2) | 84 | (14) | 7.8 | ( 1.3) |
| Small (o.6m, 0.13m/sec) | | | | | | | | |
| Alternative I | 174 | ( 29) | 35 | ( 5.9) | 26 | ( 4.3) | 5.2 | ( 0.86) |
| Alternative II | 174 | ( 29) | 24 | ( 4.0) | 26 | ( 4.3) | 3.9 | ( 0.65) |
| Alternative III | 174 | ( 29) | 16 | ( 2.6) | 26 | ( 4.3) | 2.6 | ( 0.43) |

*Figures represent emissions from a single coating line.

To quantify the reductions of national VOC emissions due to NSPS, the following assumptions are made with respect to adhesive and release use:

1) The overall effect of Regulatory Alternative I (CTG guidelines) will be to reduce existing VOC emissions by 78 percent.

2) The anticipated effect of Regulatory Alternative II (moderate NSPS regulations) is a decrease in VOC emissions of 85 percent from new PSTL coating sources.

3) The anticipated effect of Regulatory Alternative III (stringent NSPS regulations) is a decrease in VOC emissions of 90 percent from new PSTL coating sources.

4) The NSPS will go into effect in January 1981.

5) All new coating facilities will be built in the same proportion as existing facilities (i.e. in 1982, 55 percent of new coating lines will be solvent-based; in 1985, 20 percent; and in 1990, 10 percent).[5]

6) The current growth rate of tapes is 8 percent/year; for labels, 12 percent/year; for specialty products, 10 percent/ year; and for silicone release sheets, 10 percent/year.

7) The label market will grow at 12 percent/year until 1982 when growth will decline to 8 percent/year. This is also true for specialty and silicone release products.

8) The specialty market is estimated at about 83 percent of the label market (Frost and Sullivan). The specialty market will grow at the same rate as the label market.

9) The average weight percent solvent for adhesive formulations in 1978 is 66.7 weight percent. By 1982 the average should decline to 50 weight percent and remain.

10) The average adhesive coating is 30 lb/3000 ft$^2$. The average silicone coating is 0.5 lb/3000 ft$^2$.

11) The average solvent in silicone coating is 95 weight percent for 1978. It drops to 85 weight percent for 1982 and 1990.

Table 7-3 shows the effect of a NSPS on national VOC emissions from PSTL manufacturing. In general, the NSPS will result in a greater and greater effect as more sources are installed. As shown in Table 7-3, by 1990 the most stringent NSPS is predicted to show a 28 percent reduction in VOC over what would be expected if only the recommended CTG limits were in existence.

### 7.1.2 Secondary Air Pollution Impacts

Secondary environmental impacts are defined as those impacts which are not normally associated with an uncontrolled facility but result after the addition of pollution control equipment. In the case of PSTL coating facilities, the added controls are incinerators, carbon adsorption units, and hooding equipment.

The addition of incinerators to a PSTL facility can potentially result in the formation of carbon monoxide (CO) and nitrogen oxides. Carbon monoxide results from incomplete combustion of the VOC materials. As discussed in Chapter 4, the amount of CO in the incinerator effluent gas is dependent on the incineration temperature and the residence time. At temperatures above 760°C (1400°F), an incinerator should oxidize over 90 percent of all VOC to carbon dioxide.[6] Higher firebox temperatures are required for aromatic fuels than aliphatic fuels because they are more resistant to combustion.[7]

Nitrogen oxide formation in combustion units is primarily dependent on two variables: (1) excess oxygen levels and (2) firebox temperatures. The formation of $NO_x$ results from the oxidation of fuel (solvent)-bound nitrogen and from thermal fixation of nitrogen in air. The concentration of oxides of nitrogen ($NO_x$) in incinerator stack gases is about 18 to 22 ppm for natural gas-fired noncatalytic incinerators and 40 to 50 ppm for oil fired noncatalytic incinerators at a temperature of 815°C (1500°F), assuming no nitrogen containing compounds are incinerated.[8] For most solvents the nitrogen content is very low, and therefore, the emission rate should be low. One test on an incinerator-controlled pressure sensitive tape line measured the $NO_x$ concentration in the stack gas at

Table 7-3. EXPECTED NATIONAL VOC EMISSIONS FROM PSTL MANUFACTURING
(metric tons VOC/year)

| | 1978 | 1982 | 1985 | 1990 |
|---|---|---|---|---|
| Expected solvent use | 597,000 | 272,000 | 125,000 | 91,000 |
| Solvent emissions based on Alternative I | 129,000 | 59,000 | 27,400 | 19,800 |
| Solvent emissions based on Alternative II | NA | 57,600 | 24,800 | 16,600 |
| Impact on baseline emissions | NA | 1,450 | 2,600 | 3,200 |
| Solvent emissions based on Alternative III | NA | 56,500 | 23,100 | 14,300 |
| Impact on baseline emissions | NA | 2,600 | 4,300 | 5,500 |

NA - Not applicable (the NSPS will not be in effect)

16 to 28 ppm with an average of 20 ppm. This concentration equates to approximately 0.009 kg of $NO_x$ per kg of VOC destructed in the incinerator (0.009 lb $NO_x$/lb VOC.)

The major secondary air pollution impacts of carbon adsorption systems are the emissions from the boiler used for producing steam. The steam is used to strip the carbon bed of the adsorbed VOC which is then recovered in a condenser. If one assumes the boiler uses fuel oil and the regeneration of the beds require 4 kilograms of steam per kilogram of recovered solvent (4 lb steam/lb solvent), estimates can be made on the relative levels of secondary emissions. For particulates the emission rate is approximately 0.01 kilogram per kilogram of solvent recovered.[9] Sulfur dioxide emission rates are dependent on the sulfur level in the fuel. For a 0.3 weight percent sulfur fuel oil, 0.002 kilogram $SO_2$ per kilogram of solvent recovered (0.002 lb $SO_2$/lb solvent) are emitted. The magnitude of the secondary pollutants generated by the control system is much smaller than the magnitude of the VOC emissions recovered.

Cooling towers may be an additional source of secondary air pollution with a carbon adsorption unit. Particulates in cooling towers result from dissolved solids emitted to the atmosphere by cooling tower drift. This particulate emission is generally not a problem in cooling towers of the size found on carbon adsorption units.

## 7.2 WATER POLLUTION IMPACTS

There are no wastewater effluents from an uncontrolled PSTL coating facility. The only wastewater problems arise from the use of VOC pollution control equipment, and more specifically the use of carbon adsorption control equipment. The incineration controls have no wastewater discharges. The discussion in this section centers on the wastewater discharges of carbon adsorption systems.

In carbon adsorption, water is principally used to produce steam, which is then used to strip adsorbed solvent from the carbon beds. Upon completion of the stripping operation, the solvent-steam vapors are fed to a condenser. The condensed product is then allowed to separate into layers of solvent and water. The organic solvent is decanted and either reused in the coating operation or sold to a reclaimer. Three alternatives exist for reusing the decant water: (1) use the water for boiler feed; (2) use the water for cooling tower purposes; or (3) discharge the water into the local sewer or wastewater treatment facility. In the model plants developed for this study, the assumption was made to recycle 90 percent of the water as boiler feedwater. Ten percent of the total water quantity is left as wastewater.

Although recycle is highly practical, some problems may be encountered in trying to execute it successfully. The recycle water may possibly be too contaminated by organics to be used directly as boiler feed. The boiler system can be fouled and corroded by substances formed from chemical reactions between the organics and other process compounds. Treatment of the water prior to its use as boiler feed may be required. The severity of this problem can not be generalized industrywide, instead it is more plant-specific.

A schematic view of the total water cycle is shown in Figure 7-2.

### 7.2.1 Environmental Impacts

The wastewater, discharged after the solvent has been decanted, poses a potential adverse environmental impact. The potential impact results from possible organic contamination of the water. Trace concentrations of solvent may become fixed in the water during the operation of the condensation stage, even though the solvents are considered immiscible in water. The water solubilities of the more commonly used solvents are given in Table 7-4.[10, 11] The effect that the effluent will have on natural water systems is dependent on the size of the system and its sensitivity to these pollutants.

The total environmental impact from the wastewater discharges will be minimal because: (1) the total volume discharge of water is small and (2) the total emission of organics is relatively low. The estimated wastewater discharges of the individual model plant coating lines are presented in Table 7-5. These figures reflect the implementation of 90 percent recycle. In the event recycling was not possible, the correct model plant totals would be ten times the figures shown in Table 7-5.

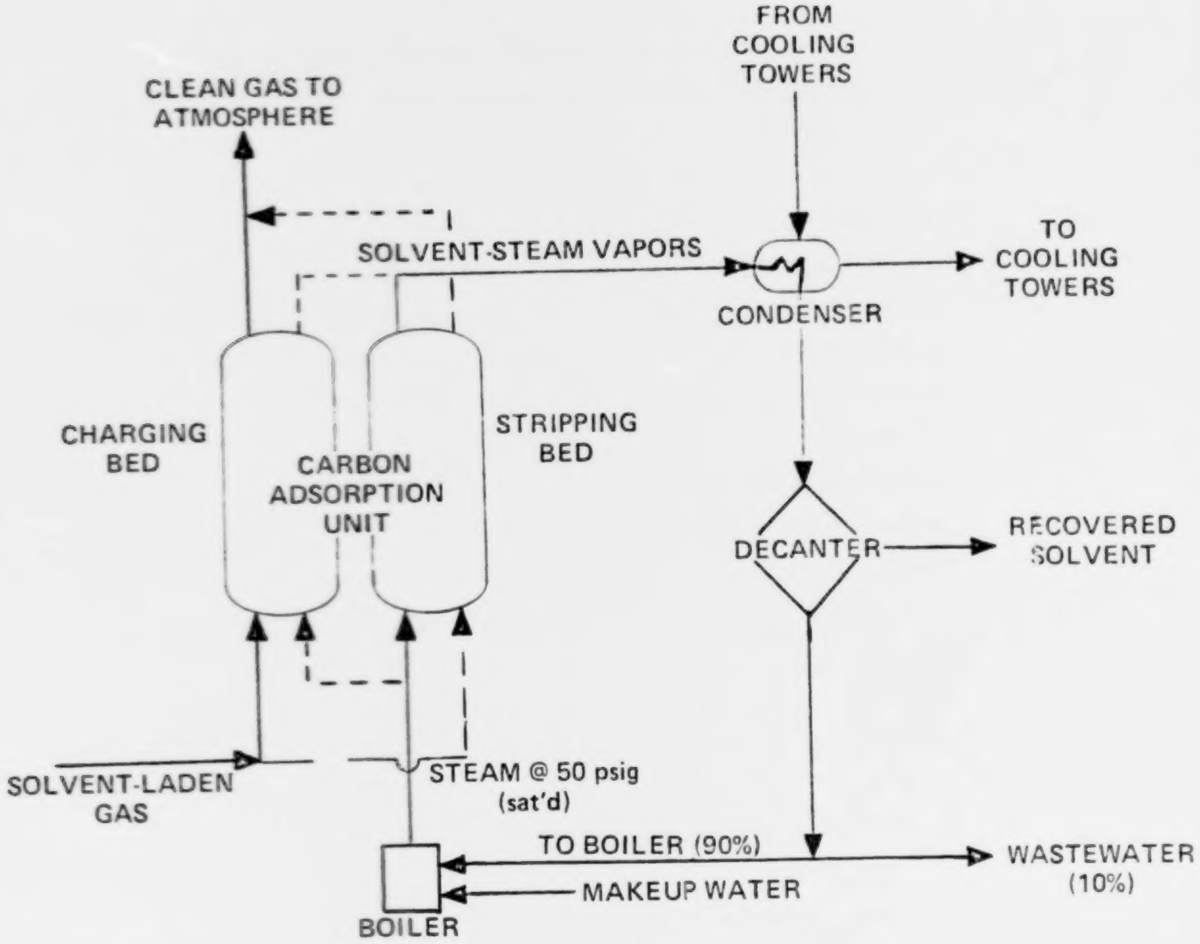
FROM COOLING TOWERS
CLEAN GAS TO ATMOSPHERE
SOLVENT-STEAM VAPORS
TO COOLING TOWERS
CONDENSER
CHARGING BED
CARBON ADSORPTION UNIT
STRIPPING BED
DECANTER
RECOVERED SOLVENT
SOLVENT-LADEN GAS
STEAM @ 50 psig (sat'd)
TO BOILER (90%)
WASTEWATER (10%)
MAKEUP WATER
BOILER

Figure 7-2. Water cycle of a carbon adsorption process.

Table 7-4. SOLVENT SOLUBILITIES IN WATER

| Solvent | Solubility in 100 Parts Water |
|---|---|
| Acetone | s. |
| n-Butyl Acetate | 0.7 |
| Carbon Tetrachloride | 0.097 (@ 0°C); 0.08 (@20°C) |
| Cyclohexane | i.; s. act. |
| Ethyl Acetate | 8.5 (@15°C) |
| Ethanol | s. |
| Methyl Acetate | 33 (@22°C) |
| Methyl Ethyl Ketone | 37 |
| Methanol | s. |
| n-Hexane | i.; s. chl. |
| n-Heptane | 0.0052 (@ 18°C) |
| Toluene | 0.05 |
| Xylene | i. |

s: soluble in all proportions

i: insoluble

s. act.: soluble in acetone

s. chl.: soluble in chloroform

## TABLE 7-5. ESTIMATED WASTEWATER DISCHARGES GENERATED BY CARBON ADSORPTION UNITS*

(Based on model plants presented in Chapter 6)

| Facility Size (line size, line speed) Control Levels | Adhesive Coating Model Plants | | Silicone Release Coating Model Plants | |
|---|---|---|---|---|
| | liters/year | (gallons/yr.) | liters/year | (gallons/yr.) |
| Large (1.5m, 1.2m/s) | | | | |
| Alternative I | 1,250,000 | (330,000) | 186,000 | (49,100) |
| Alternative II | 1,380,000 | (364,000) | 202,000 | (53,300) |
| Alternative III | 1,440,000 | (380,000) | 214,000 | (56,500) |
| Medium (0.9m, 0.3m/s) | | | | |
| Alternative I | 172,000 | ( 45,300) | 26,000 | ( 7,000) |
| Alternative II | 185,000 | ( 48,900) | 28,000 | ( 7,400) |
| Alternative III | 185,000 | ( 48,800) | 30,000 | ( 7,800) |
| Small (0.61m, 0.13m/s) | | | | |
| Alternative I | 54,500 | ( 14,400) | 8,300 | ( 2,200) |
| Alternative II | 58,700 | ( 15,500) | 8,300 | ( 2,200) |
| Alternative III | 62,500 | ( 16,500) | 9,100 | ( 2,400) |

* Figures represent emissions from a single coating line.

The total organic emission load for all plants on a national basis is given in Table 7-6. Due to of the assumption that all plants use carbon adsorption controls, the numbers given represent a worst case situation. The data in this table was based on the solvent solubilities presented in Table 7-4. A representative solvent, in this case toluene, was used to make the calculations. Toluene was chosen because of its widespread use in the industry and its favorable response in carbon adsorption systems. The organic emissions shown in Table 7-6 are small, especially when compared to the air-borne VOC emissions shown in Table 7-3. In all cases the waterborne organic load is less than 0.1 percent of the air total. A water pollution problem is not being created by the controls applied to air pollution.

The potential impacts of the organics are further lessened because of the availability of an ample number of effective water pollution control technologies. These treatment technologies include aqueous phase carbon adsorption, activated sludge treatment, oxidation of the organics, and sewer discharge to a municipal treatment facility. Of these alternatives, sewer discharge or treatment by activated carbon are the most likely ones to be used. The use of either adsorption or sludge treatment creates a solid waste problem. This small amount of solid waste would have to be landfilled or incinerated in an environmentally acceptable manner.

The responsibility for treatment of the wastewaters is generally case (or plant) specific. The existence and applicability of any local, state, or federal water laws to the water pollution situation will greatly influence the direction of the treatment procedures. The industry and the particular community will generally work out the problem of treatment to the degree that the law is satisfied. Municipalities will often absorb the burden of treatment in order to attract the industry. However, water laws which expressly prohibit the discharge of any organics-contaminated water to any source will force the burden of treatment on the industry.

TABLE 7-6. NATIONAL WATERBORNE VOC EMISSIONS FROM PSTL CARBON ADOSRPTION CONTROL UNITS

| Control Levels Facility Type | Annual VOC Emissions metric tons (tons) | | |
|---|---|---|---|
| | 1982 | 1985 | 1990 |
| Regulatory Alternative I | | | |
| Adhesive | 11.0(12.1) | 7.6(8.4) | 4.2(4.6) |
| Silicone Release | 1.6(1.8) | 1.1(1.3) | 0.62(0.68) |
| Regulatory Alternative II | | | |
| Adhesive | 12.2(13.4) | 8.4(9.3) | 4.63(5.1) |
| Silicone Release | 1.8(2.0) | 1.2(1.3) | 0.67(0.74) |
| Impact on Baseline | | | |
| Adhesive | 1.2(1.3) | 0.8(0.9) | 0.43(5.1) |
| Silicone Release | 0.2(0.2) | 0.1(neg*) | 0.05(0.06) |
| Regulatory Alternative III | | | |
| Adhesive | 13 (14) | 8.7(9.6) | 4.8(5.3) |
| Silicone Release | 1.9(2.1) | 1.3(1.4) | 0.71(0.78) |
| Impact on Basline | | | |
| Adhesive | 2.0(1.9) | 1.1(1.2) | 0.6(0.7) |
| Silicone Release | 0.3(0.3) | 0.2(0.1) | 0.09(0.10) |

Assumptions:
(1) All solvent-based coating facilities employ adsorption systems.
(2) The NSPS go into effect in January 1981.
(3) The representative solvent is toluene.
(4) The solubility of toluene is 0.05 in 100 parts water.

*neg - negligible

### 7.2.2 National Wastewater Emissions

The national wastewater discharges resulting from the implementation of carbon adsorption emission controls are presented in Table 7-7. In calculating these totals, it was assumed that every plant using a solvent-based coating technology employed carbon adsorption controls. Because of this assumption, the figures given represent a worst case situation for water discharges. The difference in wastewater discharge levels from Alternative I (Baseline) to Alternative II (Moderate) and Alternative III (Stringent) is not great. The percent increase from the baseline to the moderate control level in 1985 is 9 percent. The increase from the baseline to the stringent case in 1985 equals 13 percent. The additional wastewater is due to a higher percent of solvent recovery required for the stricter emission levels.

The combination of Tables 7-6 and 7-7 results in an overview of the national water impact in terms of water quantity and quality. The projected decline in the use of solvent-based coating is the primary factor that influences the extent to which national water quality levels will be impacted. The decline in solvent use will dictate a lessening need for carbon adsorption controls, thereby reducing both the total organics discharge and the total water effluent which would result from the controls.

## 7.3 SOLID WASTE IMPACTS

The only expected solid wastes from the add-on control systems come from the carbon adsorption units. The activated carbon in these units gradually degrades during normal operation. The efficiency of the carbon eventually drops to a level such that replacement is necessary, thereby creating a solid waste load. The amounts of waste generated annually by these beds for various sized coating facilities are presented in Table 7-8. The waste levels represent a worst case situation because all lines were assumed to be using a carbon adsorber. Additional carbon wastes will be present, but on a smaller scale, if carbon adsorption technology is used to treat the organics-contaminated wastewater. Disposal of this waste material poses minimal environmental problems.

TABLE 7-7. NATIONAL WASTEWATER EMISSIONS FROM PSTL CARBON ADSORPTION CONTROL UNITS

| Control Levels<br>Facility Type | Annual Wastewater Discharge $10^6$ liters ($10^6$ gallons) | | |
|---|---|---|---|
| | 1982 | 1985 | 1990 |
| Regulatory Alternative I | | | |
| Adhesive | 22.1(5.84) | 15.2(4.02) | 8.40(2.22) |
| Silicone Release | 3.28(0.87) | 2.26(0.60) | 1.23(0.32) |
| Regulatory Alternative II | | | |
| Adhesive | 24.3(6.42) | 16.7(4.41) | 9.25(2.45) |
| Silicone Release | 3.56(0.94) | 2.45(0.65) | 1.33(0.35) |
| Impact on Baseline | | | |
| Adhesive | 2.2 (0.58) | 1.5(0.39) | 0.85(0.23) |
| Silicone Release | 0.28(0.07) | 0.19(0.05) | 0.10(0.03) |
| Regulatory Alternative III | | | |
| Adhesive | 25.3(6.68) | 17.4(4.60) | 9.63(2.54) |
| Silicone Release | 3.78(1.00) | 2.60(0.69) | 1.41(0.37) |
| Impact on Baseline | | | |
| Adhesive | 3.2(0.84) | 2.2(0.58) | 1.23(0.32) |
| Silicone Release | 0.50(0.13) | 0.34(0.09) | 0.18(0.05) |

Assumptions:
(1) All solvent-based coating facilities employ carbon adsorption system.
(2) The NSPS go into effect in January 1981.
(3) Four kilograms of steam per kilogram of solvent recovered.
(4) Ninety (90) percent of the condensed steam is returned to the boiler.

## TABLE 7-8. ESTIMATED CARBON WASTES GENERATED BY COATING LINES CONTROLLED BY CARBON ADSORPTION*

(Based on model plants developed in Chapter 6)

| Facility Size (line size, line speed) Control Levels | Adhesive Coating Model Plants | | Silicone Release Coating Model Plants | |
|---|---|---|---|---|
| | metric tons/yr | (tons/yr) | metric tons/yr | (tons/yr) |
| Large (1.5m, 1.2m/s) | | | | |
| Alternative I | 23.2 | (25.6) | 6.92 | (7.61) |
| Alternative II | 25.6 | (28.2) | 7.52 | (8.27) |
| Alternative III | 26.8 | (29.5) | 7.95 | (8.75) |
| Medium (0.9m, 0.3m/s) | | | | |
| Alternative I | 3.19 | ( 3.51) | 0.99 | (1.08) |
| Alternative II | 3.45 | ( 3.79) | 1.04 | (1.14) |
| Alternative III | 3.44 | ( 3.78) | 1.10 | (1.21) |
| Small (0.61m, 0.13m/s) | | | | |
| Alternative I | 1.02 | ( 1.12) | 0.30 | (0.33) |
| Alternative II | 1.09 | ( 1.20) | 0.31 | (0.34) |
| Alternative III | 1.16 | ( 1.27) | 0.34 | (0.38) |

*Figures represent emissions for a single coating line.

The major solid waste problem in PSTL facilities is not a result of the air emission control options. The major problem concerns the large quantity of solid waste produced by the normal daily operation of a PSTL facility, especially if slitting operations are practiced. The wastes consist of flawed coated products, imperfect face stock, substandard release paper, and empty cartons, spools, etc. It has been estimated that 10 percent of all raw materials used in a coating operation end up as waste.[12] Therefore, for the large model plants, the waste carbon would represent approximately five (5) percent of the total solid waste load.

### 7.3.1 Environmental Impacts

The environmental effects related to the disposal of waste carbon (and sludges) are classified as secondary. Three alternatives are available for handling the waste carbon material. The three procedures involve: (1) landfilling the carbon, (2) recycling the carbon, and (3) using the carbon as fuel.

The implementation of the landfill method will be simple and efficient because the technology for the operation is considered common practice. No environmental problems should occur provided the landfill site has been properly constructed. If the site is not secured by a lining of some type (natural or artificial), possible leaching can occur. The leachate itself may contain traces of organics that are left on the carbon as residues. Transmission of this leachate into ground and surface waters can represent an adverse environmental impact.

The same type of pollution problem can occur if the waste carbon is contained in storage piles instead of landfills. The runoff from rain flowing over the piles may pick up traces or organics. The degree to which residue organics would exist on the carbon is uncertain. The carbon of each different plant would have varying quantities depending on the operational efficiency of its control process. If storage piles are used, they too should be lined by an impervious material and drainage channels should surround the entire structure. These measures will contain the possibly contaminated water so that it may be treated before release into natural systems.

The second treatment procedure involves recycling the waste carbon so that it can be reused. In this method, the spent activated carbon undergoes reactivation treatment. Once treated the carbon may be reinserted into the adsorption bed and used.

The third disposal method involves selling the waste carbon as fuel. The physical and chemical structure of the carbon in combination with the hydrocarbon residues make the wastes a fuel product similar to other solid fuels such as coal. Potential users of this fuel include industrial and small utility boilers. The revenues from selling the waste carbon may potentially help offset part of the costs of buying new activated carbon.

Since activated carbon generally contains little sulfur, furnace $SO_2$ emissions resulting from combustion will be negligible. Particulate and $NO_x$ emissions from the burning of activated carbon will be comparable to those of coal-fired furnace operations.

### 7.3.2 National Solid Waste Emissions

The estimation of the national solid waste impact as a result of NSPS is presented in Table 7-9. The assumptions used to calculate the results of each emission alternative correspond to the assumptions developed in Section 7.1.1. In addition, it was assumed that all solvent-based coating facilities use carbon adsorption control systems.

The estimates in Table 7-9 predict an overall reduction in the emission of carbon wastes with time. Projected declines in the use of solvent-based coating are responsible for these reductions. Fewer solvent processes will require fewer carbon adsorption controls.

As shown in Table 7-9, the NSPS will have a small impact on baseline solid waste emissions. In 1985 Alternative II control will result in increased solid waste emissions of about 9 percent above that generated under Alternative I control. The more stringent Alternative II control will result in increased emissions of about 14 percent above the Alternative I level. Overall, the NSPS poses no substantial environmental hazards.

## TABLE 7-9. ESTIMATED NATIONAL WASTE CARBON EMISSIONS FROM PSTL CARBON ADSORPTION UNITS

| Control Levels Facility Type | Annual Solid Waste Emissions metric tons (tons) | | |
|---|---|---|---|
| | 1982 | 1985 | 1990 |
| Regulatory Alternative I | | | |
| Adhesive | 410(450) | 281(309) | 156(172) |
| Silicone release | 122(134) | 84(92) | 46(51) |
| Regulatory Alternative II | | | |
| Adhesive | 452(497) | 310(341) | 172(187) |
| Silicone release | 132(145) | 91(100) | 49(54) |
| Impact on Baseline Emissions | | | |
| Adhesive | 42(46) | 29(32) | 16(18) |
| Silicone release | 10(11) | 7(8) | 3(3) |
| Regulatory Alternative III | | | |
| Adhesive | 471(518) | 324(356) | 179(187) |
| Silicone release | 140(154) | 96(106) | 52(57) |
| Impact on Baseline Emissions | | | |
| Adhesive | 61(67) | 43(47) | 23(25) |
| Silicone release | 18(20) | 12(13) | 6(7) |

Assumptions: (1) The NSPS goes into effect in January 1981.

## 7.4 ENERGY IMPACTS

The air emission control equipment for the PSTL industry utilizes two forms of energy: electrical energy and fossil fuel energy. The electrical energy is used in both the carbon adsorption and incineration control systems. Its primary function is to power the motors and fan used to convey gases to different sections of a control system. The fossil fuels are used in steam generation for carbon adsorption units and for supplemental fuel in incineration units.

### 7.4.1 Electricity and Fossil Fuel Impacts

The annual electricity consumptions calculated for the adhesive and silicone release model plants, using both carbon adsorption and incineration controls, are given in Table 7-10.

The generation of electricity for this purpose also causes secondary pollution effects. Whether the utility power plant is fossil fuel-fired or nuclear, some form of pollution will be emitted. Fossil fuel-fired plants will generate air emissions consisting of $SO_2$, $NO_x$, and particulates. In addition, they can generate a solid waste problem involving the disposal of residual bottom ash and flyash. Nuclear plants will produce thermal water pollution as a result of their cooling water disposal practices.

Natural gas and fuel oil (and sometimes liquid propane gas) are the types of fossil fuels used in the emission control equipment of the PSTL industry. Incinerator control systems use either fuel oil or natural gas as a supplementary fuel. As discussed in Chapter 4, the amount of supplemental fuel is dependent on the LEL in the gas to be incinerated. In the model plants developed for this study the ovens are assumed to operate at 25 percent LEL. At this level some supplemental fuel is required by the incinerators. A small amount is needed to maintain the pilot flames.

Natural gas, number 2 fuel oil, or coal can be used to fire the carbon adsorption unit boilers. In the model plants of this study, number 2 fuel oil is used. The fuel oil requirements for boilers installed

TABLE 7-10. ELECTRICITY REQUIREMENTS FOR THE CONTROL EQUIPMENT OF SOLVENT-BASED COATING LINES*
(Based on model plants developed in Chapter 6)

| Facility Size (line size, line speed) Control Levels | Adhesive Coating (GJ/yr) | | Silicone Release Coating (GJ/yr) | |
|---|---|---|---|---|
| | Carbon Adsorption | Incineration | Carbon Adsorption | Incineration |
| Large (1.5m, 1.2m/s) | | | | |
| Alternative I | 8170 | 8750 | 6610 | 6700 |
| Alternative II | 8360 | 9010 | 6610 | 6700 |
| Alternative III | 8450 | 9120 | 6610 | 6700 |
| Medium (0.9m, 0.3m/s) | | | | |
| Alternative I | 5050 | 5120 | 4700 | 4700 |
| Alternative II | 5050 | 5120 | 4700 | 4700 |
| Alternative III | 5050 | 5120 | 4700 | 4700 |
| Small (0.61m, 0.13m/s) | | | | |
| Alternative I | 3330 | 3390 | 3240 | 3240 |
| Alternative II | 3330 | 3390 | 3240 | 3240 |
| Alternative III | 3330 | 3390 | 3240 | 3240 |

*Figures represent electricity requirements of a single coating line.

on each variety of coating lines are given in Table 7-11. The natural gas requirements of each model coating line are given in Table 7-12. Most operators will want to burn liquid or gas fossil fuels over solid fossil fuels. The oil and gas fuels are much easier to store, handle and fire when compared to solid fuels. Also, because of the relatively low fuel requirements, it is expected that very few operators will use solid fossil fuels as an energy source.

### 7.4.2 National Energy Impacts

The national energy impacts from the institution of emission control technologies in the PSTL industry are presented in Tables 7-13, 7-14, and 7-15. In the calculations for these tables, it was assumed that all solvent-based coating systems are controlled by either carbon adsorption or incineration depending on the particular case. A reduction in the demands for electricity and fossil fuels is projected in every instance. These declines are due primarily to the continual shift away from solvent-based coating technology towards waterborne and 100 percent solids processes. As solvent-based coating decreases, fewer carbon adsorption and incineration systems will be needed, thereby lessening the demand for fuel oil and natural gas. The electricity consumption of solvent emission controls will also decrease for the same reason.

The impact of NSPS controls on the baseline energy requirements are minor. In 1985 Alternative II control would increase industry electricity consumption by about 2 percent above that required by Alternative I control. Alternative III would increase consumption by about 3 percent.

The fuel oil and natural gas impacts are of a similar magnitude. In 1985 Alternative II control would increase fuel oil use by about 10 percent and natural gas use by about 9 percent above that required by Alternative I control. Alternative III would result in a 15 percent increase in fuel oil consumption and about a 14 percent rise in natural gas use above baseline Alternative I levels.

Considering the national energy situation, the total additional energy used for VOC control devices is negligible (about three thousandths of one percent). This is the worst case estimate. The basis for this calculation is a national annual energy consumption of 76 x $10^{15}$ BTU's.[13]

TABLE 7-11. FUEL OIL REQUIREMENTS OF CARBON ADSORPTION CONTROL UNITS (Based on model plants developed in Chapter 6) *

| Facility Size (line size, line speed) Control Levels | Liters (Gallons) of Number 2 Fuel Oil per Year | |
|---|---|---|
| | Adhesive Coating | Silicone Release Coating |
| Large (1.5m, 1.2 m/s) | | |
| Alternative I | 885,600 (234,000) | 132,000 (34,900) |
| Alternative II | 976,300 (258,000) | 143,000 (37,800) |
| Alternative III | 1,022,000 (270,000) | 151,200 (40,000) |
| Medium (0.9m, 0.3 m/s) | | |
| Alternative I | 121,000 (32,000) | 19,400 (5,100) |
| Alternative II | 131,700 (34,800) | 19,400 (5,100) |
| Alternative III | 131,700 (34,800) | 21,600 (5,700) |
| Small (0.61m, 01.3 m/s) | | |
| Alternative I | 38,900 (10,300) | 6,500 (1,700) |
| Alternative II | 41,000 (10,800) | 6,500 (1,700) |
| Alternative III | 43,200 (11,400) | 6,500 (1,700) |

*Figures represent fuel oil requirements of a single coating line.

TABLE 7-12. NATURAL GAS REQUIREMENTS FOR THE CONTROL EQUIPMENT OF SOLVENT-BASED COATING LINES*

| Facility Size (line size, line speed) Control Levels | Adhesive Coating Lines ($Nm^3/yr$) | Silicone Release Coating Lines ($Nm^3/yr$) |
|---|---|---|
| Large (1.5m, 1.2 m/s) | | |
| Alternative I | 2,304,000 | 343,200 |
| Alternative II | 2,496,000 | 371,400 |
| Alternative III | 2,646,000 | 395,400 |
| Medium (0.9m, 0.3 m/s) | | |
| Alternative I | 315,600 | 49,800 |
| Alternative II | 332,400 | 51,600 |
| Alternative III | 337,200 | 54,000 |
| Small (0.61m, 0.13 m/s) | | |
| Alternative I | 99,600 | 15,000 |
| Alternative II | 180,000 | 15,000 |
| Alternative III | 114,600 | 17,400 |

* Is used in incineration systems only

## TABLE 7-13. ESTIMATED NATIONAL ELECTRICITY IMPACTS OF VOC CONTROL SYSTEMS

| Total Carbon Adsorption Control | Annual Electricity Consumption (GJ/yr) 1982 | 1985 | 1990 | Total Incineration Control | Annual Electricity Consumption (GJ/yr) 1982 | 1985 | 1990 |
|---|---|---|---|---|---|---|---|
| Regulatory Alternative I | | | | Regulatory Alternative I | | | |
| Adhesive | 207,400 | 142,600 | 82,000 | Adhesive | 218,200 | 151,200 | 86,400 |
| Silicone Release | 177,100 | 123,100 | 67,000 | Silicone Release | 179,300 | 125,300 | 67,000 |
| Regulatory Alternative II | | | | Regulatory Alternative II | | | |
| Adhesive | 211,700 | 144,700 | 84,200 | Adhesive | 224,700 | 153,400 | 88,600 |
| Silicone Release | 177,100 | 123,100 | 67,000 | Silicone Release | 179,300 | 125,300 | 67,000 |
| Impact on Baseline | | | | Impact on Baseline | | | |
| Adhesive | 4,300 | 2,100 | 2,200 | Adhesive | 6,500 | 2,200 | 2,200 |
| Silicone Release | 0 | 0 | 0 | Silicone Release | 0 | 0 | 0 |
| Regulatory Alternative III | | | | Regulatory Alternative III | | | |
| Adhesive | 213,900 | 146,900 | 84,200 | Adhesive | 226,800 | 155,500 | 88,600 |
| Silicone Release | 177,100 | 123,100 | 67,000 | Silicone Release | 179,300 | 125,300 | 67,000 |
| Impact on Baseline | | | | Impact on Baseline | | | |
| Adhesive | 6,500 | 4,300 | 2,200 | Adhesive | 8,600 | 4,300 | 2,200 |
| Silicone Release | 0 | 0 | 0 | Silicone Release | 0 | 0 | 0 |

Assumptions: (1) NSPS go into effect in January 1981.
(2) All values reflect the combined adhesive and silicone release requirements.
(3) All coating lines are controlled by either incineration or carbon adsorption.

TABLE 7-14. ESTIMATED NATIONAL FUEL OIL IMPACTS OF VOC CONTROL SYSTEMS*

| Control Levels Facility Type | Annual Consumption of Number 2 Fuel Oil-$10^6$ liters ($10^6$ gallons) | | |
|---|---|---|---|
| | 1982 | 1985 | 1990 |
| Regulatory Alternative I | | | |
| Adhesive | 15.6(4.1) | 10.7(2.8) | 6.0(1.6) |
| Silicone Release | 2.3(0.61) | 1.6(0.42) | 0.88(0.23) |
| Regulatory Alternative II | | | |
| Adhesive | 17.2(4.5) | 11.8(3.1) | 6.5(1.7) |
| Silicone Release | 2.5(0.66) | 1.7(0.45) | 0.94(0.25) |
| Impact on Baseline | | | |
| Adhesive | 1.6(0.42) | 1.1(0.29) | 0.5(0.13) |
| Silicone Release | 0.2(0.05) | 0.1(0.03) | 0.06(0.02) |
| Regulatory Alternative III | | | |
| Adhesive | 18.0(4.8) | 12.3(3.2) | 6.8(1.8) |
| Silicone Release | 2.7(0.71) | 1.8(0.48) | 1.0(0.20) |
| Impact on Baseline | | | |
| Adhesive | 2.4(0.63) | 1.6(0.42) | 0.8(0.21) |
| Silicone Release | 0.4(0.11) | 0.2(0.05) | 0.12(0.03) |

*Is used in carbon adsorption systems only

TABLE 7-15. ESTIMATED NATIONAL NATURAL GAS IMPACTS OF VOC CONTROL SYSTEMS*

| Control Levels Facility Type | Annual Natural Gas Consumption ($10^6 Nm^3$) | | |
|---|---|---|---|
| | 1982 | 1985 | 1990 |
| Regulatory Alternative I | | | |
| Adhesive | 40.7 | 27.9 | 15.5 |
| Silicone Release | 6.1 | 4.2 | 2.3 |
| Regulatory Alternative II | | | |
| Adhesive | 44.0 | 30.2 | 16.7 |
| Silicone Release | 6.5 | 4.5 | 2.4 |
| Impact on Baseline | | | |
| Adhesive | 3.3 | 2.3 | 1.2 |
| Silicone Release | 0.4 | 0.3 | 0.1 |
| Regulatory Alternative III | | | |
| Adhesive | 46.5 | 31.9 | 17.7 |
| Silicone Release | 7.0 | 4.8 | 2.7 |
| Impact on Baseline | | | |
| Adhesive | 5.8 | 4.0 | 2.2 |
| Silicone Release | 0.9 | 0.6 | 0.4 |

* Is used in incineration systems only

There is a potential in the PSTL industry for a net national energy savings. This savings would be possible if many or all solvent-based coating lines used solvent recovery control systems. The net recovered solvent could be translated into barrels of oil, consequently equaling barrels of oil that would not then have to be imported.

In 1985, Regulatory Alternative II would have an increased energy requirement of about 7,900 barrels (1.26 million liters) of crude oil per year above that required by Regulatory Alternative I. If all solvent-based lines were controlled by carbon adsorption to the Alternative II level (a best case situation) gross energy savings of about 23,600 barrels (3.75 million liters) of crude oil are estimated. By deducting the required energy for controls, a potential net national energy savings of 15,700 barrels (2.5 million liters) of crude oil exists.

If all solvent-based coating lines were controlled by incineration to the Alternative II level the worst case national energy impacts result. Because no solvent is recovered, there are no credits to offset the increased energy used by the VOC control systems. Annually 17,700 barrels (2.8 million liters) of crude oil may be consumed by the PSTL industry.

Under Regulatory Alternative III an incremental (above Alternative I) energy demand of approximately 12,000 barrels (1.9 million liters) of crude oil is projected. Assuming all solvent-based coating lines are controlled to the Alternative III level by carbon adsorption, a gross national energy savings of about 39,100 barrels (6.2 million liters) of crude oil is predicted. This gross savings equates to a potential net national energy savings of 27,100 barrels (4.3 million liters) of crude oil. This estimate reflects the best case energy impact.

The worst case energy situation would occur if incinerators were used to control all solvent-based coating lines. All solvent would be destructed and no recovery value could be obtained. Under Alternative III incineration controls would require approximately 31,000 barrels (4.9 million liters) of crude oil per year.

No total carbon adsorption or total incineration control situation is anticipated in this industry. The actual energy impact will be determined by the availability of price of solvent, the applicability of alternative fuels, the rapidity with which low-solvent technologies replace solvent-based ones, and the stringency of environmental regulations.

## 7.5 OTHER ENVIRONMENTAL IMPACTS

The impact of increased noise levels is not a significant problem within the emission control systems of the PSTL industry. No noticeable increases in noise levels occur as a result of increasingly stricter regulatory alternatives. Fans and motors, present in the majority of the systems, are responsible for the bulk of the noise in the control operations.

## 7.6 REFERENCES

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# 8. ECONOMIC IMPACT

## 8.1 INDUSTRY PROFILE

### 8.1.1 Introduction

Pressure sensitive adhesives (PSA's) are technically defined as those in which a dry film is agressively and permanently tacky at room temperature and which will bond firmly to a large variety of untreated surfaces with only minimal finger pressure. The pressure sensitive adhesives industry generally includes those producers of the adhesive components, formulators of the adhesive compounds, and manufacturers of products coated with PSA's. The segment of the industry treated in this document is limited to manufacturers of PSA-coated materials. There are three major categories of PSA-coated products: tapes, labels, and specialty items.

The major difficulty in accurately profiling the pressure sensitive tapes and labels (PSTL) industry is a lack of data. The industry is classified under Standard Industrial Classification (SIC) 26414, a part of SIC 2641, paper coating and glazing. Since data are not as readily available for five-digit industries as they are for four-digit industries, it is impossible to supply quantitative information for certain parts of this profile.

### 8.1.2 General Profile

8.1.2.1 Supply. The objective of this section is to examine elements of the supply of PSTL. This involves a description of the product, the process by which it is produced, and identification of firms in the industry.

Product description. Pressure sensitive tapes and labels are found in a wide variety of forms and have an enormous range of uses. The tapes and labels produced may be used directly by the consumer as mending tape or unprinted labels; however, pressure sensitive tapes and labels are often used as an intermediate good. In such products tapes may be used as fasteners, as on disposable diapers, while preprinted labels may decorate and identify the product. Therefore, the market is not only influenced by direct consumer demands for the tapes and labels, but also by consumer demand for the final product of which tapes and labels are a part. Pressure sensitive tapes and labels have found uses in a wide variety of markets, such as the automotive industry, building construction, electronics, graphic arts, general manufacturing, and everyday consumer needs in business and at home.

There are nearly 600 different types of pressure sensitive tapes produced.[1] The major categories are established according to the backing material used: paper, film, fabric, foam, nonwoven fabric, and foil tapes. The largest volume of tapes produced are paper backed tapes, estimated to account for approximately 40 percent of the tape market in 1974.[2] The three major uses of paper tape are listed according to volume usage: masking, packaging, and surface protection. Masking tape has its largest market concentrated in the automotive industry, but is further used in home painting, drafting, and other general applications. Packaging tapes are thicker and stronger than masking tape and are used throughout many industries. Surface protection of highly polished product surfaces or surfaces which are easily scratched is a major market for saturated paper tape.

Film tapes, which are backed by different polymer films, are second in volumetric production and use. Plastic backed tape has been estimated to control from 24 to 31 percent of the total market.[3] Cellophane was the most important backing material used and provided us with the first household/office pressure sensitive tape; however, other improved polymer films, such as cellulose acetate, are gaining the lead. Films such as polyester film are used for general household tape, but more importantly in glass reinforced tape. Polyvinylchloride is used in both rigid and plasticized forms. Rigid polyvinylchloride tape has become popular for packaging and box sealing and placticized polyvinylchloride is used for electrician tape, pipe wrap tape, and hospital bandage tape.

Polypropylene and polyethylene are used for tape backing for a variety of uses, but not nearly to the extent of the other four films.

Fabric tapes made with cotton cloth backing are useful for surgical and athletic applications because of their high strength and bulk and flexibility. Polymer coated cloth tapes are also produced for use in duct insulation and carpet pad splicing. Other cloth tapes include acetate cloth and glass fiber cloth.

Other pressure sensitive tape backing materials are foam, nonwoven fabric, and foil. Foam tapes are useful in gasketting and weather stripping. Nonwoven fabric tapes are important as hospital tapes. Foil tapes are commonly made of aluminum, lead, and copper foils and find uses in packaging and sealing, heat shielding, insulating, and sound and vibration damping.

Tapes may be either double or single sided and may also come in other forms such as embossible tape or photoprintable tape. Some tapes may be mounted on release liners, others may just receive a release coat, and then some may not be release coated at all. Coating and marketing of release backing is another large, closely associated business.

Labels are all provided with release liners and are primarily made from castcoated paper. Other papers are also used, and many are clay coated to provide a better printing surface. Labels are categorized primarily as printed or unprinted. Pressure sensitive labels have gained tremendously in use on product containers and as decorative decals.

Production process. The production stages for the PSTL industry are shown in Figure 8-1. The chemical industry manufactures the raw materials used in compounding the adhesive and the polymer web materials. The paper web materials are supplied by the pulp and paper industry. Often, the adhesive component materials are sold to adhesive formulators who compound the raw materials into bulk adhesives appropriate for manufacturing different products. Tape and label manufacturers then buy the compounded adhesives from formulators, or in the case of most large manufacturers, the adhesive raw materials are bought directly from the chemical firms and formulated in-house. Release papers or release coated webs may be bought from companies who are solely involved in

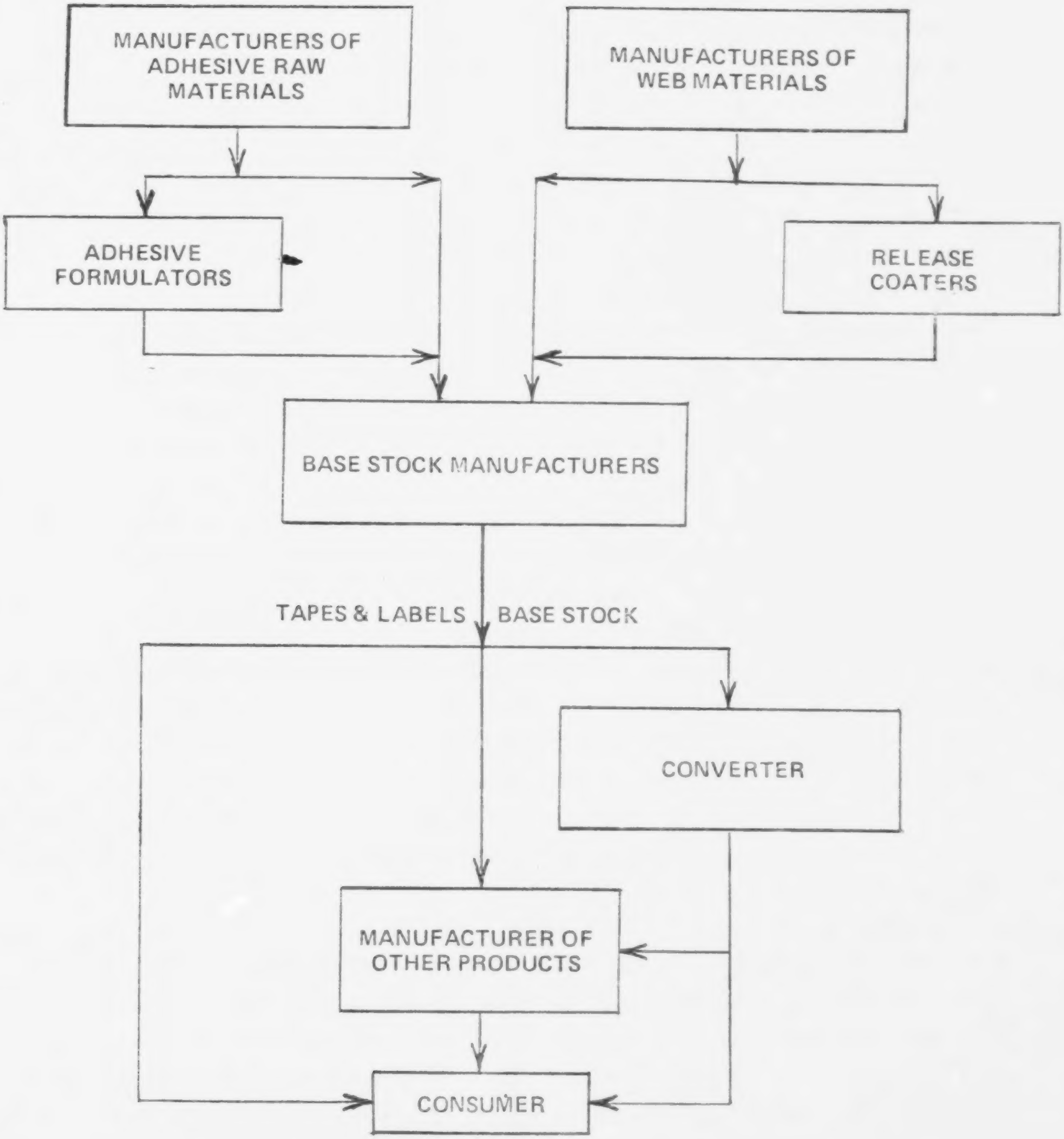
MANUFACTURERS OF ADHESIVE RAW MATERIALS
MANUFACTURERS OF WEB MATERIALS
ADHESIVE FORMULATORS
RELEASE COATERS
BASE STOCK MANUFACTURERS
TAPES & LABELS
BASE STOCK
CONVERTER
MANUFACTURER OF OTHER PRODUCTS
CONSUMER

Figure 8-1. Hierarchy of the pressure sensitive tapes and labels industry.

release coating operations or they may be coated in-house. The base stock materials for the tapes and labels are manufactured in a wide sheet or web, and either further processed into tapes or labels on site or sold to converters to be further processed at another site. The web or base stock is processed into tapes, labels, or similar products and sold as a final product or sold to manufacturers as an intermediate good.

The manufacturing of labels involves higher volume and lower technology than that found in the pressure sensitive tape business. As a result, the two segments of the industry have in general remained separate, even though the basic production processes are similar.

Current industry technology is based upon hydrocarbon (solvent) application of the adhesive. Solvent-based coatings account for 60-70 percent of pressure sensitive tape production, waterborne coatings account for 20 percent, and hot melt for 10 percent.[4] This distribution of production methods could easily change depending upon the availability of factors of production. Much of the natural rubber used in the production of solvent adhesives comes from Malaysia and Indonesia, two relatively unstable political structures. As a result of dollar devaluation and heavy demands for more natural rubber in the production of other products, these countries have raised the price of their shipments by 15-20 percent. Toluene, which is used as a solvent, is a petroleum derivative and subject to OPEC supply constraints.

Firms in the industry. In this study nearly 90 firms with production coating lines for pressure sensitive tapes and labels were identified. Table 8-1 provides a list of these firms, their location, the principal product categories, and the number of workers employed by each. Sixty individual firms operate these facilities. The distribution of firms is shown graphically in Figure 8-2.

Silicone release sheet coating. Release coating operations are an integral part of the total pressure sensitive tape and label industry. Nearly all tapes or labels have some release coating associated with them. While most tapes are back-side coated with a release coating, most labels and some tapes require a separate piece of coated substrate known as a release. The following paragraphs discuss the release sheet coating industry.

Table 8-1. PRESSURE SENSITIVE TAPES AND LABELS PRODUCTION FACILITIES POTENTIALLY INCLUDING COATING OPERATIONS
(a) EXCEPT AS NOTED

| Adhesive Company | Plant Location | Major Product | No. Employees |
|---|---|---|---|
| Action Manufacturing | Gonic, NH | Tapes | |
| American Biltrite (Accurate Hampton) | Garfield, NJ | Tapes | 185 |
| Adchem | Westbury, NY | Tapes | 50 |
| Adhesives Products | Los Angeles, CA | Labels & Specialties | 90 |
| Adhesives Research | Glen Rock, PA | Tapes & Labels | 65 |
| Advance Process Supply | Chicago, IL | Tapes & Labels | 300 |
| American White Cross Labs | New Rochelle, NY | Surgical and Industrial Tapes | 200 |
| Anchor Continental | Columbia, SC | Tapes | 375 |
| Arlon Products | Compton, CA<br>Marysville, MI | Tapes | 170 |
| Armak (Tape Division) | Chicago, IL | Tapes & Specialties | 357 |
| Arno Adhesive Tapes (Scholl,Inc.) | Michigan City, IN | Tapes | 400 |
| Atlantic Gummed Paper Corp. | Brooklyn, NY | Paper Tapes | 250 |
| Avery (Avery Label Division) | Monrovia, CA | Labels | |
| (Fasson) | Painesville, OH | | 1000-2499$^{(d)}$ |
| (Fasson) | Quakertown, PA | P-S Paper, films, foils, and tapes | 250-499$^{(d)}$ |
| (Fasson) | Cucamonga, CA | | |
| (Fasson) | Peach Tree City,GA | | 50-99$^{(d)}$ |
| Betham Corporation | Middlesex, NJ | Tapes | 40 |
| Brady-Technicote Division | Milwaukee, WI | Tapes and Labels | 20-49$^{(d)}$ |
| Brown-Bridge Mills | Troy, OH | Labels | |
| Conrad-Hanovia, Inc. | Newark, NJ | Phosphorescent Tape | 225 |
| Central Paper Company | Menasha, WI | Labels | 100-249$^{(d)}$ |
| Chamoplast, Inc. | Wayne, NJ | Films and Tapes | 10 |

### Table 8-1 (continued). PRESSURE SENSITIVE TAPES AND LABELS PRODUCTION FACILITIES POTENTIALLY INCLUDING COATING OPERATIONS (a) EXCEPT AS NOTED

| Adhesive Company | Plant Location | Major Product | No.Employees |
|---|---|---|---|
| Chemtrol | Aurora, OH(c) | Tapes and Graphic Supplies(c) | 100-249(b) |
| Coated Products, Inc. | Monmouth Junction, NJ | Labels & Label Stock | 100 |
| Connecticut Hard Rubber | New Haven, CT | Tape | 90 |
| Custom Coating and Laminating | Worcester, MA | Tapes & Labels | 35 |
| Daubert Chemical | Cullman, AL(d)<br>Chicago, IL<br>McKinney, Texas | Release paper<br>Release paper<br>Tapes | 500-999(d) |
| Deccofelt | Glendora, CA | Felt Tape | 45 |
| Delco Rubber Corporation | Millbury, MA | Rubber sheet | 30(e) |
| Dennison | Framingham, MA | Label Stock | 140 |
| Dymo | Berkeley, CA | Embossed Tape Labels | |
| Engineered Coated Products | Chicago, Il | Tapes | |
| Fitchburg Coated Products Division | Moosic, PA | Label Stock & Tapes | 335 |
| Fuller Paste and Adhesive | Pittsburgh, PA | Tapes | 40 |
| General Formulation (General Research) | Sparta, MI | Tapes | 30 |
| Ideal Tape (Chelsea Industries) | Lowell, MA | Tapes | 105 |
| James River Graphics | South Hadley, MA | Labels | 35 |
| Jonergin | St. Albans, VT | Labels | |
| Kendall (Polyken Division) | Franklin, KY | Industrial and Hospital Tapes | |
| Kent Manufacturing | Grand Rapids, MI | Tapes | 20 |
| Kleen-Stik (Essex Chemical) | Monmouth Junction, NJ | Packaging Tapes & Labels(c) | |
| Labelmaster (Modular Products Corp.) | Chicago, IL | Tapes & Labels | 35 |

Table 8-1 (continued). PRESSURE SENSITIVE TAPES AND LABELS PRODUCTION FACILITIES POTENTIALLY INCLUDING COATING OPERATIONS
(a) EXCEPT AS NOTED

| Adhesive Company | Plant Location | Major Product | No.Employees |
|---|---|---|---|
| Labelon | Canandaigua, NY | Tapes & Labels[c] | 160[e] |
| Lamart | Clifton, NJ | Tapes & Specialties | 55[e] |
| LePage's Inc. | Gloucester, MA | Tapes & Labels | 155 |
| Ludlow Corp. | Chicago, IL | | 100-249[d] |
| Mask-Off | Monrovia, CA | Tapes & Labels | 30 |
| Monarch Marking Systems | Huntington Beach, CA[d] | | 250-499[d] |
| Morgan Adhesives (Bemis Corporation) | Stow, OH | Tapes & Labels | 460[e] |
| Mystik Tape (Borden Chemical) | Northfield, IL | Tapes & Labels | 500 |
| Nashua (Label Division) | Nashua, NH | Label Stock | |
| (Industrial Tape Division) | Chicago, IL | Industrial Tapes | 300 |
| No-Lik Labels (Werby) | Framingham, MA[d] | Labels | 20-50[d] |
| Northern Adhesives Co. | Brooklyn, NY | Tapes | |
| Norton Specialties Co. | Worcester, MA | Tapes | 20 |
| Norwood Industries, Inc. | Malvern, PA | Tape or Label | |
| October Company | Easthampton, MA | | |
| Odell Company | Watertown, MA | Tapes | ± 35 |
| Permacel (Johnson & Johnson) | New Brunswick, NJ | Industrial Tapes | |
| Plymouth Rubber | Canton, MA | Tapes | 650 |
| Pres-On Products | Addison, IL | Tapes | 35 |
| Presto Adhesive Paper | Miamisburg, OH | Tapes & Label stock | 75 |
| Quantum Tape (DeWall Industries) | Wallingford, CT | Tapes | 160 |

Table 8-1 (continued). PRESSURE SENSITIVE TAPES AND LABELS PRODUCTION FACILITIES POTENTIALLY INCLUDING COATING OPERATIONS
(a) EXCEPT AS NOTED

| Adhesive Company | Plant Location | Major Product | No.Employees |
|---|---|---|---|
| Rexham Corporation | Matthews, NC | Tapes | 160 |
| Richards/Parents, & Murray | Mt. Vernon, NY | Tapes and foam tape | 25 |
| Shawsheen Rubber | Andover, MA | Tapes | 35 |
| Sheldahl (Advanced Products Div.) | Northfield, MN | Tapes | 180[e] |
| Shuford Mills | Hickory, NC | Tapes | 350 |
| Syntac | Cleveland, OH | Tapes & Labels | 35 |
| T and F Industries | Rolling Meadows, IL | Tapes | 50 |
| Tapecoat | Evanston, IL | Tapes | 40 |
| Tesa | South Hackensack, NJ[c] | Packaging Tape and Equipment[c] | |
| 3M (Minnesota Mining and Manufacturing) | Hutchinson, MN | Tape | 1000-2500[d] |
| | St. Paul, MN | Tape | |
| | Bedford,Park, IL | Tape | |
| | Bristol, PA | Tape | 500-1000[d] |
| | Knoxville, IA | Tape | 250-500[d] |
| | Greenville, SC | Tape | |
| | Brookings, SD | Tape | |
| | Freehold, NJ | Tape | |
| Tuck Industries | Beacon, NY | | |
| | Carbondale, IL | Tape | 1055 |
| | Passaic, NJ | | |

Table 8-1 (continued). PRESSURE SENSITIVE TAPES AND LABELS PRODUCTION FACILITIES POTENTIALLY INCLUDING COATING OPERATIONS (a) EXCEPT AS NOTED

| Adhesive Company | Plant Location | Major Product | No. Employees |
|---|---|---|---|
| S. D. Warren (Scott Paper Co.) | Boston, MA | Label Stock | |

---

(a) 1978 Adhesives Red Book, Palmerton Publishing, Atlanta, Georgia.

(b) 1978 Thomas Register

(c) Frost & Sullivan, Pressure Sensitive Products and Adhesives Market, November 1978.

(d) Predicasts computer search, 16 March 1979

(e) Radian telephone survey of manufacturers

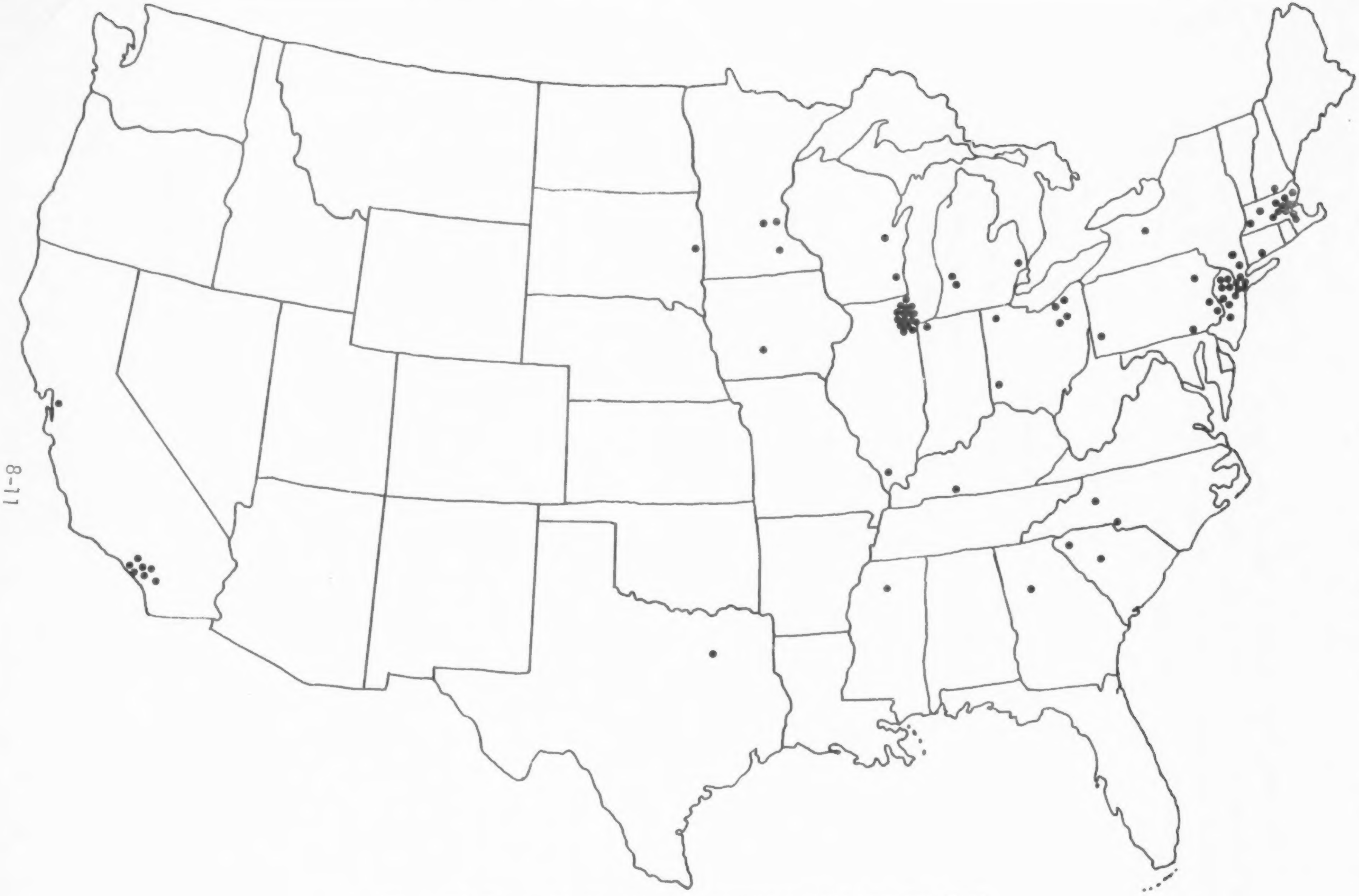

Figure 8-2. Geographical locations of pressure sensitive tapes and labels coating operations in the United States

The production growth of the release sheet industry is near 10 percent annually.[5] This growth rate is closely associated with the growth of the label industry. The total volume of silicone release paper coated in 1978 was approximately two and one-half billion square meters (3 billion square yards).[6] Silicone release sheet coating is done by two types of firms: (1) pressure sensitive tape or label manufacturers who operate the release coaters in-line with their adhesive coating equipment and (2) independent coaters whose only business is coating silicone release sheets. The majority of silicone release coating is done for captive uses. The largest purchasers of the release coatings include 3M Company, Avery-Fasson, Dennison Manufacturing Company, and Morgan Adhesives. Of these, Avery-Fasson, Dennison, and Morgan are major label and label stock manufacturers.

In May 1979 a survey was made of operations which coat only silicone release sheet materials and then sell the release sheets to pressure sensitive tape or label manufacturers.[7] Nine companies were identified that strictly coat release sheets. Of these nine only seven actually coat materials used in the pressure sensitive tapes and labels industry. These seven operate nine plants and seventeen organic, solvent-based coating lines. Only two plants operate more than one coating line. The companies identified as release sheet coaters are given in Table 8-2.

The results of the silicone release coater survey are outlined in Table 8-3. In 1978, companies coating just release materials produced about 441,000,000 square meters (527,000,000 square yards) of release coated webs. Of this total, approximately 243,000,000 square meters (291,000,000 square yards), or 55 percent, were sold to manufacturers of pressure sensitive tape and label products. This production represents 9.7 percent of all silicone release coated sheets for the industry.

For operations which strictly coat release sheets, the coating is generally a high volume operation with few small specialty lines. Release coaters operate at high speeds with large web widths. Line speeds range from 45 to 366 meters per minute (150 to 1200 feet per minute) with an average speed of 144 meters per minute (470 feet per minute). Web widths in the industry range from 102 to 223 centimeters

TABLE 8-2. MAJOR SILICONE RELEASE COATING COMPANIES

| Pressure Sensitive Release Coater | Plant Location |
|---|---|
| Akrosil Division | Menasha, Wisconsin |
| ARHCO, Inc. | West Chicago, Illinois |
| Daubert Chemical Co. | Dixon, Illinois<br>Cullman, Alabama<br>McKinney, Texas |
| Eastern Fine Paper | Brewer, Maine |
| H.P. Smith | Chicago, Illinois<br>Iowa City, Iowa |
| James River-Massachusetts,Inc. | Fitchburg, Massachusetts |
| Ludlow Papers & Flexible Pkg. | Chicago, Illinois |
| Rhinelander Paper Co. | Rhinelander, Wisconsin |
| St. Regis Paper Co. | Attleboro, Massachusetts |

### TABLE 8-3. SILICONE RELEASE SHEET COATING DATA FOR COMPANIES SOLELY INVOLVED IN RELEASE COATING

PRODUCTION

Total Release Coating Production - 441,000,000 $m^2$

Total Release Coating Related to PSTL - 243,000,000 $m^2$

Percent of Total Production Related to PSTL - 55%

OPERATING CONDITIONS

Range of Web Width - 1.0 to 2.2 m (40 to 88 inches)

Average Web Width - 1.5 m (61 inches)

Range of Line Speeds: 0.76 to 6.1 m/sec (150-1200 feet/minute)

Average Line Speed - 2.4 m/sec (470 feet/minute)

Percent of Production that is Solvent-Based - 78%

Percent of Production that is Waterborne - 19%

Percent of Production that is 100 Percent Solids-Based - 3%

Average Weight Percent Solvent - 91.8%

(40 to 88 inches) with an average width of 155 centimeters (61 inches). Paper, paperboard, polyolefin paper, clay coated paper, plastic coated paper, supercalendered kraft, and unsupported films (polyester, polyethylene, polystyrene) constitute the majority of materials used in the webs.

The silicone release survey showed that 78 of all silicone release sheet coatings are solvent-based. Toluene, heptane, xylene, naphtha, and alcohols are the preferred solvents. Current solvent-based silicone release coatings have an average weight percent solvent of 91.8. None of the surveyed coaters employed any type of solvent control technology.

Of the remaining coatings 86 percent are waterborne and 14 percent are 100 percent solids. Industry-wide the trend is to go to low-solvent technologies rather than solvent systems with VOC controls. By 1982 predictions indicate that silicone release coating will be performed by one-third solvent, one-third waterborne, and one-third 100 percent solids technology. Most of the conversions will occur in larger firms, while smaller companies will remain solvent-based. The move towards low solvent systems will reduce the impact of the independent release sheet coaters on the PSTL source category.

8.1.2.2 Demand. This section examines factors relevant to the demand side of the PSTL market, such as sales, imports and exports, and substitutes and complements.

Growth of sales. The sale of pressure sensitive tapes and labels totals approximately $1.3 billion per year. Pressure sensitive tape shipments account for $900 million and pressure sensitive labels account for $360 million.[8] Growth for the industry is high when compared to both a broader industrial classification and to industry in general, as shown in Table 8-4. In the 5 years since 1973, sales of pressure sensitive tapes and labels have increased by over 50 percent, the largest growth of any sector in SIC 2641.[9] On the average, the PSA market has grown at 10 percent annually, while labels have increased at 12 percent.[10] Typically, the demand for pressure sensitive tapes and labels follows general business activity fairly closely. This is due to its use as an intermediate good by major industrial users, e.g., the automotive industry.[11]

### TABLE 8-4. PERCENTAGE GROWTH IN VALUE OF SHIPMENTS 1958-1972

| Period | SIC 26414[a] | SIC 2641[a] | All industry[b] |
|---|---|---|---|
| 1958-1963 | 70 | 44 | 29 |
| 1963-1967 | 41 | 7 | 33 |
| 1967-1972 | 31 | 22 | 35 |

[a] U.S. Bureau of Census, Census of Manufactures, 1972. *Industry Series: Converted Paper and Paperboard Products, Except Containers and Boxes*, GPO, 1975, p. 30.

[b] U.S. Bureau of Census, Census of Manufactures, 1972, Vol. 1, *Subject and Special Statistics*, GPO, 1976, p. 3.

There appears to be no data on production in terms of square yards or pounds, nor present percentage of production capacity being utilized.

Demand for specialty pressure sensitive products are presented in Table 8-5.

For most firms demand does not exhibit any seasonal variations, as sales figures are roughly constant throughout the year.[12] This contributes to fuller capacity utilization.

### TABLE 8-5. SALES AND USAGE FIGURES FOR SPECIALTY PRESSURE SENSITIVE PRODUCTS, 1978

| Tape Type or Major Use | Sales, (mm$) | Usage, mm $m^2$ (mm $yd^2$) |
|---|---|---|
| Health and first aid tape | | |
| Fasteners for disposable diapers | | 10(12) |
| Fasteners for feminine napkins | | 38(45) |
| Pipe wrap tape | 40 | |
| Hospital tape | 30 | |
| Narrow slit drafting tape | | 0.25(.3) |

Imports and exports. Imports, until recently, have not been considered a threat by domestic manufacturers. However, one particular area of concern is the volume of rigid polyvinylchloride tape imported from some European countries. In the other pressure sensitive market areas there appears to be only a small percentage of import competition. Table 8-6 shows 1978 pressure sensitive tape imports by various categories.[13] Plastic backed tapes are the largest import item in volume and in dollar value. Table 8-7 shows a time trend for imported plastic backed pressure sensitive tape.[14] The major exporting countries of pressure sensitive tapes are Italy, West Germany, and Taiwan.

The impact on the pressure sensitive tapes market by imports was first realized several years ago when several West German and Italian operations unloaded large quantities of unplasticized (rigid) PVC box tape on the market.[15] More recently, manufacturers have become concerned over possible dumping by Taiwan. Thus, the potential for imports to pose a significant threat to the U.S. market for pressure sensitive tape exists.

Exports of PSTL are an important part of the industry. For example, in 1977 approximately 60 percent of Morgan Adhesives' sales were outside the United States.[16] Recent export statistics for pressure sensitive tape are presented in Table 8-8.[17]

Additional import and export data is available through the U.S. Trade Commission; however, product classifications have changed from year to year and it is difficult to determine what products were included for a given year.[18,19] It is impossible to draw any correlation due to the incongruity encountered. Projections of imports and exports are not available.

Substitute and complementary goods. There has been a great deal of competition between pressure sensitive labels and those that are heat or water activated. Pressure sensitive labels are more expensive, but they are less expensively applied and capital equipment costs are less.[20] These factors, coupled with advancement in new pressure sensitive adhesives and compatible application rates with production lines, have made them

Table 8-6 . 1978 PRESSURE SENSITIVE TAPE IMPORTS

| Product category | $M^2 X10^6$ | $(yd^2 X10^6)$ | $kg X10^6$ | $(lb X10^6)$ | $\$(X10^6)$ |
|---|---|---|---|---|---|
| Filament reinforced pressure sensitive tapes | 6.38 | (7.63) | 0.76 | (1.67) | 1.80 |
| Pressure sensitive tapes - electrical | 24.5 | (29.3) | 3.47 | (7.65) | 6.49 |
| Plastic backed pressure sensitive tapes | 125.3 | (149.8) | 12.1 | (26.72) | 25.45 |
| Pressure sensitive tape, not specifically provided for | 23.8 | (28.46) | 2.02 | (4.45) | 5.92 |

Table 8-7 . U.S. IMPORTS OF PRESSURE SENSITIVE PLASTIC BACKED TAPE

| Type of tape | 1973 | 1974 | 1975 | 1976 |
|---|---|---|---|---|
| Unplasticized PVC | | | | |
| 1000 m$^2$ | 18,802 | 28,373 | 32,081 | 53,440 |
| (1000 yd$^2$) | (22,487) | (33,935) | (38,370) | (63,915) |
| \$1000 | 4382 | 7581 | 7133 | 12,079 |
| Polypropylene | | | | |
| 1000 m$^2$ | 34 | 218 | 784 | 6,060 |
| (1000 yd$^2$) | (41) | (261) | (938) | (7,248) |
| \$1000 | 32 | 53 | 179 | 1241 |
| Polyester | | | | |
| 1000 m$^2$ | 23 | 12 | 8 | 19 |
| (1000 yd$^2$) | (28) | (14) | (9) | (23) |
| \$1000 | 1 | 19 | 12 | 23 |
| Other Plastic | | | | |
| 1000 m$^2$ | 38 | 18 | 44 | 110 |
| (1000 yd$^2$) | (45) | (21) | (53) | (132) |
| \$1000 | 16 | 9 | 25 | 61 |
| Total | | | | |
| 1000 m$^2$ | 18,897 | 28,621 | 32,918 | 59,630 |
| (1000 yd$^2$) | (22,601) | (34,231) | (39,370) | (71,318) |
| \$1000 | 4431 | 7662 | 7349 | 13,404 |

Table 8-8. 1978 PRESSURE SENSITIVE TAPE EXPORTS

| Product category | Quantity | | Value |
|---|---|---|---|
| | kg X $10^6$ | (lb X $10^6$) | \$ X $10^6$ |
| Pressure sensitive tape with plastic backing, not elsewhere specified | 50.9 | (112.2) | 81.3 |
| Pressure sensitive tape with paper or paperboard backing | 10.7 | (23.55) | 32.4 |
| Pressure sensitive tape with rubberized textile backing | 2.02 | (4.46) | 8.64 |
| Pressure sensitive tape, sheets, strips, and other flat shapes or forms (other than listed above) | 5.81 | (12.8) | 20.2 |

very competitive for use in the labeling of commercial products. Some of the recent growth of pressure sensitive adhesives has come at the expense of substitutes. For example, the adhesives' share of the fastener market has grown from 37 percent in 1965 to 45 percent in 1977.[21]

Demand for PSTL has also been affected by the demand for complementary commodities. Disposable diapers and feminine napkins are examples of new products using tapes and fasteners. Foam tapes similar to those used as automobile body side moldings are also being used in new markets such as acoustics and insulation. In addition to new complementary uses of PSTL, increased demand for existing complements, e.g., automobiles, also increases demand.

### 8.1.3 Market Structure

This section presents information on the organization of the pressure sensitive tapes and labels industry. Data on industry size and geographic concentration, vertical and horizontal integration, and entry and exit of firms in the industry will be presented. An attempt is made to estimate the size distribution of firms in the industry, but reliable data on pressure sensitive tapes and labels sales by firm are unavailable.

8.1.3.1 Concentration Characteristics. Traditional indicators of industry concentration show a relatively high degree of concentration. As shown in Table 8-9 the industry has become less concentrated over time.[22]

Table 8-9. HISTORIC CONCENTRATION RATIOS OF PRESSURE SENSITIVE TAPES DEFINED BY VALUE OF SHIPMENTS

| Year | Total Shipments (millions of dollars) | 4-Firm Ratio | 8-Firm Ratio | 20-Firm Ratio | 50-Firm Ratio |
|---|---|---|---|---|---|
| 1972 | 574.5 | .59 | .74 | .90 | .98 |
| 1967 | 438.3 | .68 | .81 | .94 | .99 |
| 1963 | 311.7 | .65 | .76 | .92 | .99 |
| 1958 | 183.4 | .76 | .88 | .97 | .99 |
| 1954 | 148.9 | D | .95 | .98 | NA |

D: Withheld to avoid disclosing figures for individual companies.

To characterize the PSTL industry as highly concentrated may be somewhat misleading. As discussed above, output of the industry is not homogenous. For example, paper tape is different from foil tape. Thus, in most cases they do not represent substitutes for each other. In some markets within the paper tapes and labels classification, high concentration ratios may be the norm, while in others product sales may be more evenly distributed. For example, the production of masking tape is dominated by a few large firms such as Minnesota Mining and Manufacturing and Tuck Industries. This results from the production process in which large batch production runs enable the producer to take advantage of large economies of scale. However, with specialty tapes the runs are smaller, often custom ordered, suggesting the existence of numerous smaller firms with sales more evenly distributed. In spite of the above qualification, it should be noted that concentration ratios have on the whole fallen through time. This would indicate that this market is becoming more competitive.

Reliable statistics of firm sales of PSTL are unavailable. Thus it is difficult to obtain individual market shares of the sales leaders. Listed below in Table 8-10 are sales leaders for tapes and labels in estimated order of market share.[23]

TABLE 8-10. RANKING OF FIRMS BY ESTIMATED MARKET SHARE
(largest to smallest)

| Pressure Sensitive Tapes | Label Stock |
|---|---|
| 1. Minnesota Mining and Manufacturing | 1. Avery/Fasson |
| 2. Permacel | 2. Morgan |
| 3. Nashua Corp. | 3. Dennison |
| 4. Mystik Tape | 4. S. D. Warren |
| 5. Tuck Industries | 5. Fitchburg |
| | 6. Coated Products Inc. |

Geographic concentration. Geographically, production for paper tapes is concentrated in the North Central region of the United States as indicated in Table 8-11. This distribution probably best describes the distribution of production and sales for the entire industry. Based on this distribution and the present estimates of total industry product sales, the regional value of shipments for all pressure sensitive tapes and labels manufacturers would approximate the figures presented in Table 8-11.[24]

Table 8-11. ESTIMATED REGIONAL DISTRIBUTION OF PRESSURE SENSITIVE TAPES AND LABELS SHIPMENTS (excluding finished labels)

| U.S. Production Shipment | Percentage of Total U.S. Shipment Value, 1972 | Estimated Present Value of Shipments |
|---|---|---|
| Northeast | 28% | $300 mm |
| North Central | 61% | 670 mm |
| South | 8% | 90 mm |
| West | 3% | 30 mm |

Those states with pressure sensitive tapes and labels shipments in the top tier by dollar value are Illinois and Minnesota, according to 1972 Department of Commerce data.[25] States which rank in the second tier are Massachusetts, New York, New Jersey, Pennsylvania, Ohio, Michigan, and Kentucky. Pressure sensitive tapes became less geographically concentrated between 1967 and 1972, with both the North Central and Northeast losing market shares to the South and West.[26]

Integration. Again a deficiency of information prohibits a rigorous treatment of vertical and horizontal integration within the industry. A few observations can be advanced that may be suggestive. As noted in the discussion of the production process the potential for vertical integration exists, especially in the acquisition of inputs. For example, converters have begun to install their own coating lines instead of buying the base stock elsewhere (e.g., Werby Industries, S.D. Warren). Vertical integration also exists at the output stage. For example, Presto Adhesive Paper Company produces pressure sensitive adhesive paper, over 50 percent of which is sold to its parent company, Monarch Marketing

Company.[24] In another instance, Arno Adhesive Tapes sells 20 percent of its output to Scholl, Inc., its parent.[28] Thus it appears that the potential for vertical integration to contribute toward more efficient operation exists, although the extent of such integration in the industry is unknown. Integration of various other adhesive applications, for example heat sensitive, exists within firms producing pressure sensitive adhesives (e.g., Deccofelt Corp., Shawseen Rubber, and Werby Industries). The extent of such horizontal integration is unknown.

8.1.3.2 Entry and Exit of Firms. The pressure sensitive tapes and labels industry is roughly 20 years old. Much of the initial entry occurred when existing firms established pressure sensitive adhesive coating operations. It is difficult to obtain concrete information about such diversification. From the available data, it can be seen that new entrants are relatively few, as shown in Table 8-12.[29] Data on the exit of firms from the PSTL industry is unavailable.

TABLE 8-12. ENTRY TO THE PRESSURE SENSITIVE TAPES AND LABELS INDUSTRY SINCE 1964[a]

| Time Period | Number of Firms |
|---|---|
| 1977-1979 | 2 |
| 1974-1977 | 1 |
| 1964-1974 | 8 |

[a] Firms included in this table were selected from those of Table 8-1.

### 8.1.4 Market Conduct

The intent of this section is to characterize the PSTL industry with respect to economic decision variables, particularly its pricing behavior. Due to the variety of products included under pressure sensitive tapes and labels, it is difficult to specify a price that is representative of the industry's output. For example, in 1972 the price of various tape products ranged from \$1.00 to \$9.00 per square meter (\$0.85 to \$7.50 per square yard).[30]

From the available information it is however difficult to suggest on what basis price is determined. In some segments of the market, where there are numerous competitors and relatively low barriers to entry, it is expected that price closely reflects factor costs. If this is the case, then a competitive model of price determination is appropriate. In others where only a few firms produce the goods and capitalization costs are high, an oligopolistic model better represents pricing decisions. In general, the competitive pricing model yields lower profit margins and more efficient use of plant and equipment. For example, firms in a market characterized by a competitive pricing model are more likely to exploit any economies of scale that may exist.

The available information is insufficient to permit a characterization of price determination of the pressure sensitive tapes and labels industry or any of its submarkets. The type of information necessary for specifying a model would include:

- the degree to which various submarkets are technical substitutes, and
- cost and price information for specific firms in the various submarkets of the industry.

While it is difficult to suggest a model of price determination, limited information on price trends is available. Recent prices for various plastic tapes are shown in Table 8-13.[31,32] The relationship of output price to factor prices is shown in Figure 8-3.[33] It suggests that output price is sensitive to costs of inputs but a clear pattern is not discernable. Finally, prices of inputs are given in Table 8-14. The cost of petroleum based inputs, such as toluene, have risen to reflect increased prices of crude oil.

### 8.1.5 Market Performance

The objective of this section is to examine specific indicators of performance. In large part, this involves an examination of the financial characteristics of the firms in the industry. Specific variables constructed below will be employed in the quantitative analysis of the impacts of the regulatory options presented in Section 8.4.

## Table 8-13 . PRICE TRENDS OF PLASTIC TAPES

(dollars/$m^2$)

| | 1973 | 1974 | 1975 | 1976 | 1977 |
|---|---|---|---|---|---|
| UPVC* | | | | | |
| U.S. Production | | | | | |
| Imported Tapes | 0.23 | 0.27 | 0,22-0.38 | 0.22-0.42 | 0.22-0.42 |
| Polypropylene | | | | | |
| U.S. Production | | | 0.25-0.41 | 0.23-0.40 | 0.23-0.40 |
| Imported Tapes | | | 0.28-0.37 | 0.21-0.31 | 0.21-0.31 |
| Polyesters | | | | | |
| U.S. Production | | | | | |
| Imported Tapes | | | 1.58 | 1.50 | 1.21 |
| Other Plastic Tapes | | | | | |
| U.S. Production | | | | | |
| Imported Tapes | 0.42 | 0.50 | 0.57 | 0.55 | |
| Total Plastic Tapes | | | | | |
| U.S. Production | | | 0.45 | 0.43 | 0.41 |
| Imported Tapes | 0.23 | 0.27 | 0.22 | 0.22 | |

*Unplasticized Polyvinylchloride

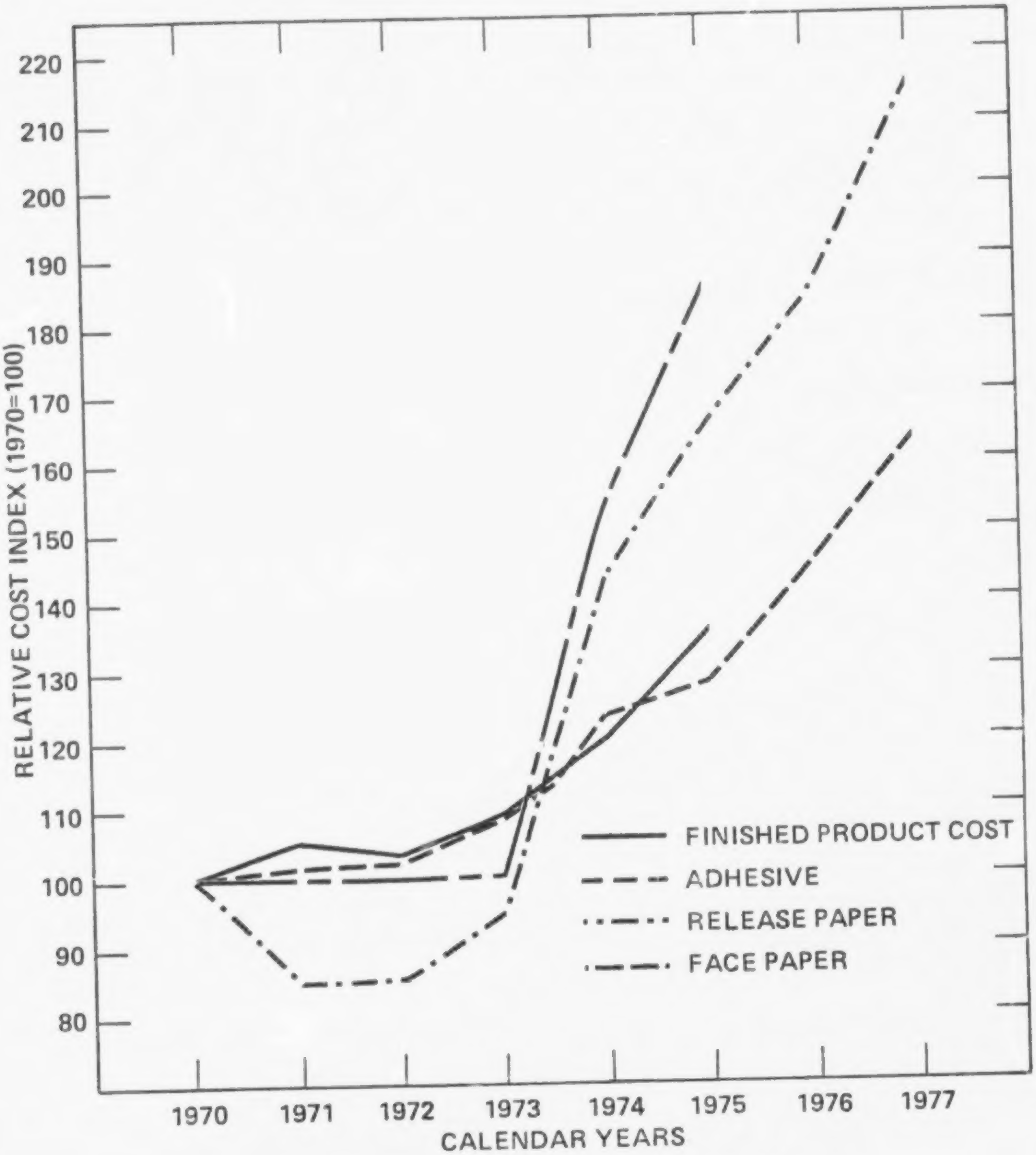

Figure 8-3. Production costs versus raw material costs.
Note: Costs for 1976 and 1977 are projected costs.

Table 8-14. RAW MATERIAL COSTS FOR PRESSURE SENSITIVE TAPES AND LABEL PRODUCTS

| Web Materials | 1979 Price (dollars/unit) |
|---|---|
| Crepe paper | 0.036/sq yd |
| Flat back paper | 0.018 - 0.048/sq yd |
| Release control paper tape stock | 0.060 - 0.15/sq yd |
| Release coater paper label stock | 0.060 - 0.10/sq yd |
| Mylar | 0.046 - 0.084/sq yd |
| Cellophane | 0.074 - 0.16/sq yd |
| Polypropylene | 0.064 - 0.079/sq yd |
| Import Rigid PVC | 0.042/sq yd |
| Aluminum foil | 0.067 - 0.172/sq yd |
| Silicone Release | 2.00 - 4.00/lb |
| Toluene | 1.00 - 1.25/gallon |
| Tackifying Resins | |
| Petroleum hydrocarbons | 0.26 - 0.48/lb |
| Resin Esters | 0.35 - 0.40/lb |
| Polyterpenes | 0.35 - 0.44/lb |
| Elastomers | |
| Natural rubber | 0.50 - 0.70/lb |
| Kraton ™ | 0.75/lb |
| Acrylics (dry) | 0.75 - 0.80/lb |
| Hot melt formulations | 0.75 - 0.80/lb |
| Purchased acrylic solvent (per pound of dry acrylic) | 1.60/lb |
| Acrylic emulsion (per pound of dry acrylic) | 0.85/lb |

Cost Data comes from the following sources: Akrosil, Mosinee Paper, DuPont, Hercules, Kaiser Aluminum, Shell, Union Carbide, and Frost & Sullivan

#### 8.1.5.1 Financial Profile.

Size distribution of firms. A variety of parameters are relevant in evaluating the financial status of a firm or industry. A broad indicator of firm size is sales. The sales data presented in Table 8-15. are not specific to pressure sensitive tapes and labels but rather are total sales for firms in the PSTL industry, many of whom produce other products. As this table indicates, many of the firms in the industry are quite large; nearly 40 percent have sales in excess of $100 million annually. Another characteristic of the industry is the broad range of firm sizes, varying from total sales of less than $3 million to well over $1 billion.

Table 8-16 presents selected financial data for firms in the industry. These data include sales, number of employees, total assets, and net worth. The results illustrate the diversity of firms in the industry.

Balance sheet indicators. The balance sheet ratios presented in Table 8-17 are of greater analytic interest than the sales data. The table shows for each firm, grouped by sales class size (see Table 8-16), its return to assets, return to net worth, and the ratio of cash to assets. Return to assets is the firm's net income after taxes divided by total assets. It indicates the productivity of a firm's assets. In comparison to the paper and forest products industry, of which the PSTL industry is a part, many firms perform favorably. The PSTL industry mean is 6.8 percent, while the paper and forest products group mean is 7.0 percent.[34]

Return to net worth is net income after taxes divided by the equity of common stock holders. It is a good guage of earnings ability across firms or industries. A composite of 400 industrial firms has a return to net worth ratio of 14.0 percent.[35] The average for the firms in Table 8-17 is 19.0 percent. If the small size firms are excluded the average falls to 12.8 percent. Including the small firms may bias the ratio upward, since the data were often unverified estimates supplied by the firms themselves. This contrasts with the data for the larger publicly traded firms, which have been verified by an audit. In spite of this qualification, the PSTL industry has an earnings ability at least equal to the industrial average and possibly above it.

TABLE 8-15 . DISTRIBUTION OF SALES VOLUME FOR FIRMS IN PRESSURE SENSITIVE TAPES AND LABELS INDUSTRY[a]

| Sales volume in million $ | Number of firms | % of total |
|---|---|---|
| 1. Less than 3 | 8 | 14.3 |
| 2. 3-4.9 | 8 | 14.3 |
| 3. 5-9 | 8 | 14.3 |
| 4. 10-49 | 6 | 10.7 |
| 5. 50-99 | 4 | 7.1 |
| 6. 100-499 | 9 | 16.1 |
| 7. 500-999 | 3 | 5.4 |
| 8. 1000 + | 10 | 17.9 |
|  | 56 |  |

[a] Based on this distribution firms (e.g., cost of capital values) were divided into three sizes: Small, 0-4.9 million dollars of sales; Medium, 5-499 million dollars; and Large, 500 million dollars and more.

## TABLE 8-16 . FINANCIAL DATA FOR COATING FIRMS[a,b]

| | | Sales[c] category | Sales (000$) | Employees | Total assets (000$) | Net worth (000$) | Sources;[d] and date of yr. end for financial data[e] |
|---|---|---|---|---|---|---|---|
| 1. | Action Mfg. | NA | NA | 20 | NA | NA | D+B; 6/30/78 |
| 2. | American Biltrite | M | 192,176 | 4,000 | 116,012 | 46,540 | M; 12/31/77 |
| 3. | Adchem | S | 1,000 | 52 | NA | NA | D+B; 9/29/78 |
| 4. | Adhesive Products | S | 3,000 | 90 | NA | NA | D+B; estimate |
| 5. | Adhesive Research | M | 5,000 | 65 | 2,752 | 1,166 | D+B; 6/30/78 |
| 6. | Advance Process Supply | M | 10,000 | 300 | NA | NA | D+B; estimate |
| 7. | American White Cross Labs | M | 7,908 | 200 | 2,577 | 822 | D+B; 12/31/77 |
| 8. | Anchor Continental | M | 26,000 | 540 | 13,052 | 6,861 | D+B; 6/30/78 |
| 9. | Arlon Products | M | 6,916 | 165 | 3,727 | 1,209 | D+B; 11/30/77 |
| 10. | Armak (Akzona) | L | 808,847 | 15,165 | 674,937 | 304,184 | M; 12/31/77 |
| 11. | Arno Adhesive Tape (Scholl, Inc.) | M | 216,440 | | 121,517 | 64,410 | S+P; 12/31/77 |
| 12. | Atlantic Gummed Paper Corp. | | | | | | |
| 13. | Avery International Corp. | M | 423,541 | 3,000 | 278,858 | 132,658 | M; 11/30/77 |
| 14. | Betham Corp. | S | 4,500 | 50 | NA | NA | D+B; 12/31/78 |
| 15. | Brady | M | 5,400 | 28 | NA | NA | D+B; 3/2/78 |
| 16. | Brown Bridge Mills (Kimberly Clark) | L | 1,725,500 | 28,545 | 1,651,300 | 905,500 | M; 12/31/77 |
| 17. | Central Paper Co. (Alco Standard Corp.) | L | 1,541,268 | 14,500 | 606,071 | 251,568 | D+B; 9/30/78 |
| 18. | Chemplast, Inc. | M | 14,071 | 279 | 9,745 | 7,094 | M; 8/31/77 |
| 19. | Chemtrol | NA | NA | 140 | NA | NA | D+B; NA |
| 20. | Coated Products, Inc. (Essex) | M | 76,835 | 599 | 44,686 | 22,034 | S+P; 12/31/77 |
| 21. | Connecticut Hard Rubber (Armco) | L | 3,549,239 | 50,135 | 2,882,274 | 1,451,514 | M; 11/31/77 |
| 22. | Conrad Hanovia | | | | | | |
| 23. | Custom Coating and Laminating | S | 3,181 | 35 | 1,284 | 220 | D+B; 6/30/77 |
| 24. | Danbert Chemical (Hinsdale, Ill.) | M | 29,000 | 300 | NA | NA | D+B; 4/23/79 |
| 25. | Deccofelt | S | 3,000 | 60 | NA | NA | D+B; 3/7/79 |

(con.)

TABLE 8-16 (continued).

| | | Sales[c] category | Sales (000$) | Employees | Total assets (000$) | Net worth (000$) | Sources;[d] and date of yr. end for financial data[e] |
|---|---|---|---|---|---|---|---|
| 26. | Delco Rubber Corp. | | | | | | |
| 27. | Dennison | M | 356,129 | 8,000 | 207,941 | 129,787 | M; 12/31/77 |
| 28. | Dymo | M | 209,845 | 5,500 | 120,489 | 55,327 | M; 6/20/77 |
| 29. | Fitchburg Coated Products (Litton) | L | 3,442,924 | 94,000 | 2,063,809 | 861,308 | M; 7/31/77 |
| 30. | Fuller Paste and Adhesive (Fuller H.B.) | M | 219,962 | 3,300 | 116,222 | 44,710 | S+P; 11/30/78 |
| 31. | General Formulations | S | 4,500 | 65 | 2,500 | 965 | D+B; estimate |
| 32. | Ideal Tape (Chelsea) | M | 185,724 | 2,865 | 106,753 | 42,551 | M; 10/1/77 |
| 33. | Jonergin | | | | | | |
| 34. | Kendall, Boston | L | 500,000 | 11,700 | 212,722 | 146,279 | D+B; 12/31/77 |
| 35. | Kent | S | 2,400 | 23 | 644 | 417 | D+B; 10/31/77 |
| 36. | Kleen Stik | | | | | | |
| 37. | Labelmaster | M | 5,000 | 35 | 2,000 | 1,610 | D+B; estimate |
| 38. | Labelon | M | 7,978 | 225 | NA | 813 | D+B; 10/2/76 |
| 39. | Lamart | S | 3,572 | 41 | 1,496 | 721 | D+B; 12/31/77 |
| 40. | LePage, Inc. (Papercraft) | | | | | | |
| 41. | Ludlow | M | 215,764 | 3,440 | 114,289 | 55,470 | M; 12/31/77 |
| 42. | Mask-Off | S | 1,242 | 35 | 864 | 408 | D+B; 6/30/76 |
| 43. | Minnesota Mining and Mfg. | L | 3,980,376 | 81,400 | 3,529,597 | 2,269,296 | M; 12/31/77 |
| 44. | Monarch Marketing System (Pitney Bowes) | L | 605,973 | 18,649 | 523,737 | 196,178 | M; 12/31/77 |
| 45. | Morgan Adhesives Co. | M | 76,347 | 825 | NA | 23,386 | M; 12/31/77 |
| 46. | Mystik Tape (Borden) | L | 3,481,278 | 37,800 | 1,901,625 | 1,024,691 | M; 12/31/77 |
| 47. | Nashua | M | 410,990 | 6,113 | 200,909 | 101,679 | M; 12/31/77 |
| 48. | No-Lik Labels (Werby, Ind.) | NA | NA | 40 | NA | NA | D+B; 8/4/78 |
| 49. | Nothern Adhesives Co. | S | 1,000 | 20 | NA | NA | D+B; 6/7/79 |
| 50. | Norton Specialties | L | 959,946 | 24,400 | 707,795 | 347,308 | S+P; 12/31/78 |
| 51. | Norwood Ind. (Seton) | M | 52,537 | 800 | 25,471 | 9,428 | M; 12/31/77 |
| 52. | October Co. | S | 3,800 | 82 | 3,137 | 2,503 | D+B; 3/31/78 |
| 53. | Odell Co. | S | 3,500 | 50 | 1,382 | 877 | D+B; 6/30/78 |
| 54. | Parmacel (Johnson and Johnson) | L | 2,914,081 | 60,500 | 2,019,792 | 1,480,026 | M; 1/1/78 |

(con.)

TABLE 8-16 (continued).

| | | Sales[c] category | Sales (000$) | Employees | Total assets (000$) | Net worth (000$) | Sources;[d] and date of yr. end for financial data[e] |
|---|---|---|---|---|---|---|---|
| 55. | Plymouth Rubber | M | 49,502 | 1,000 | 25,221 | 13,343 | M; 12/31/77 |
| 56. | Press-on Products | | | | | | |
| 57. | Presto Adhesive Paper (Monarch Market) | M | 7,835 | 70 | NA | NA | D+B; 4/27/79 |
| 58. | Quantum Tape | S | 4,500 | 150 | NA | NA | D+B; 6/30/78 |
| 59. | Rexham Corp. | M | 110,680 | 2,044 | 72,927 | 54,043 | M; 1/1/78 |
| 60. | Richards, Parent and Murray | S | 1,500 | 27 | NA | NA | D+B; 1/29/79 |
| 61. | Scott Graphics (Scott) | L | 1,520,226 | 21,300 | 1,589,466 | 870,341 | M; 12/31/77 |
| 62. | Shawsheen Rubber | S | 1,200 | 45 | 753 | 607 | D+B; 12/31/78 |
| 63. | Sheldahl | M | 37,857 | 1,007 | 23,854 | 6,850 | S+P; 8/31/78 |
| 64. | Shuford Mills | M | 91,000 | 1,800 | 54,187 | 30,130 | D+B; 12/31/77 |
| 65. | Syntac | S | 2,300 | 28 | 748 | 96 | D+B; 3/31/78 |
| 66. | T and F Industries | S | 2,109 | 46 | 1,479 | 364 | D+B; 10/31/77 |
| 67. | Tapecoat (TC Manufacturing) | M | 8,400 | 18 | 4,565 | 2,453 | D+B; 10/31/77 |
| 68. | Tesa | | | | | | |
| 69. | Tuck Industries (Technical Tape) | M | 67,943 | 1,055 | 35,188 | 16,619 | M; 12/31/77 |
| 70. | S. D. Warren (Scott) | L | 1,520,226 | 21,300 | 1,589,466 | 870,341 | M; 12/31/77 |

[a] List of firms obtained from Table 8.1-4, section 8.1.1.4.

[b] In some cases financial data represents that for a parent firm. If so, the parent is listed below the subsidiary, in parentheses.

[c] Sales are categorized in Table 8.1-3.

[d] Sources of information:
D+B: Dunn and Bradstreet Reports
M: Moody's Industrial Manual
S+P: Standard and Poor's Corporation Records

[e] Date indicates year-end period for financial data.

## TABLE 8-17. SELECTED FINANCIAL PARAMETERS FOR FIRMS GROUPED BY SIZE CLASSIFICATION (BASED ON SALES)[a]

| Firm | Return to Assets | Return to Net Worth | Cash to Assets |
|---|---|---|---|
| A. Small (less than 5 million dollars) | | | |
| 1. Custom Coating and Laminating | .148 | .864 | .135 |
| 2. General Formulations | NA | NA | .041 |
| 3. Kent Mfg. | NA | NA | .221 |
| 4. Mask-Off | .037 | .667 | NA |
| 5. October Co. | NA | NA | .064 |
| 6. Odell Co. | NA | NA | .297 |
| 7. Syntac | .067 | .521 | .011 |
| 8. T & F Ind. | .141 | .580 | .023 |
| Weighted Mean | .110 | .665 | .096 |
| B. Medium (5-499 million dollars) | | | |
| 1. American Biltrite | .105 | .263 | .009 |
| 2. American White Cross | .065 | .204 | .003 |
| 3. Arlon Products | .048 | .148 | .033 |
| 4. Arno Adhesives (Scholl, Inc.) | .061 | .114 | .063 |
| 5. Avery | .055 | .116 | .029 |
| 6. Chemplast, Inc. | .121 | .167 | .117 |
| 7. Coated Products, Inc. (Essex) | .091 | .190 | .019 |
| 8. Dennison | .090 | .143 | .011 |
| 9. Dymo | .039 | .086 | .083 |
| 10. Fuller Paste and Adhesive (Fuller H. B.) | .061 | .159 | .093 |
| 11. Ideal Tape (Chelsea Ind.) | .019 | .047 | .033 |
| 12. Label Master | NA | NA | .150 |
| 13. Ludlow Corp. | .007 | .013 | .021 |
| 14. Morgan Adhesives (Bemis) | .048 | .106 | .015 |
| 15. Nashua | .077 | .150 | .032 |
| 16. Norwood Industries (Seton) | .055 | .150 | .019 |
| 17. Plymouth Rubber | .004 | .008 | .020 |
| 18. Rexham Corp. | .081 | .109 | .030 |
| 19. Sheldahl | .017 | .059 | .029 |
| 20. Tuck Industries (Technical Tape) | .074 | .156 | .020 |
| Weighted Mean | .067 | .122 | .037 |
| C. Large (500 million dollars and more) | | | |
| 1. Armak (Akzona) | .011 | .025 | .014 |
| 2. Brown Bridge Mills (Kimberly Clark) | .079 | .144 | .015 |
| 3. Central Paper Co. (Alco Standard) | .079 | .190 | .020 |
| 4. Connecticut Hard Rubber (Armco) | .042 | .083 | .007 |
| 5. Fitchburg Coated Products Div. (Litton) | .027 | .065 | .036 |

(con.)

TABLE 8-17 (continued).

| | Firm | Return to Assets | Return to Net Worth | Cash to Assets |
|---|---|---|---|---|
| 6. | Kendall (Colgate Palmolive) | .081 | .155 | .027 |
| 7. | Monarch Marketing Syst. (Pitney Bowes) | .072 | .193 | .015 |
| 8. | Mystik Tape (Borden) | .067 | .124 | .071 |
| 9. | Norton Specialties (Norton) | .088 | .178 | .011 |
| 10. | Parmacel (Johnson & Johnson) | .122 | .167 | .033 |
| 11. | Scott Graphics, S. D. Warren (Scott) | .062 | .110 | .004 |
| 12. | Minnesota Mining & Manufacturing | .177 | .182 | .102 |
| Weighted Mean | | .082 | .135 | .043 |

[a] In some cases financial data represent those for a parent firm. If so, the parent is listed with the subsidiary, in parentheses.

Cash to assets, the third ratio in Table 8-17, is defined as cash to total assets. It indicates a firm's or industry's ability to invest in plant or equipment. Firms in the PSTL industry have an average ratio of 4.8 percent; the average for the paper and forest products group was 6.7 percent in 1976.[36]

Cost of capital. The cost of capital is the cost of financing investment projects. It is an important financial parameter for two reasons. First, in purely a descriptive sense, it reflects the capital structure of a firm or industry, that is, the distribution of capital between debt and equity sources. It is an indicator of the target rate of return that firms must receive on new investment if the value of the firm is to increase over time. Second, the information presented in this section is used in the economic impact analysis in section 8.4.

Table 8-18 presents cost of capital data for 27 firms in the PSTL industry. In general, the firms listed represent only the larger ones found in Table 8-16. Data for the smaller firms were insufficient to estimate the cost of capital. Investment is financed out of either debt or equity. Equity is the sum of retained earnings, common stock at par value, and other stockholder equity, e.g., paid in surplus. Debt capital is the sum of long-term bonds and notes.

When debt and equity sources are compared, the majority of capital expenditures are financed out of equity. The weighted average for equity finance is 85 percent, with only 15 percent debt financed. This suggests that debt finance plays only a minor role in the firm's cost of capital.

The cost of equity capital is the cost to the firm of financing an investment by increasing equity in the firm.[37] In theory, this involves computing the rate of return paid to common stockholders. Two methods have been developed to measure this rate of return, depending upon what assumptions are made regarding the future growth of the firm. The first is the dividend method. It assumes that dividend payments remain constant over time and that there will be no growth. Mathematically, it is calculated as the dividend price ratio:

$$k_e' = \frac{D_o}{P_o}$$

TABLE 8-18. FINANCIAL DATA USED TO CALCULATE COST OF CAPITAL FOR FIRMS AND INDUSTRY[a,b]

| Firm | Total[c] capital (000$) | Percent equity financed | Percent debt financed | Cost of equity | | |
|---|---|---|---|---|---|---|
| | | | | Dividend method | Gordon-Shapiro method | Solomon method |
| 1. American Biltrite | 69,540 | 67 | 33 | 1.35 | 10.70 | 20.00 |
| 2. Armak (Akzona) | 367,184 | 83 | 17 | 6.53 | 10.42 | 14.29 |
| 3. Avery International | 167,658 | 79 | 21 | 3.15 | 14.24 | 12.50 |
| 4. Brown Bridge Mills (Kimberly Clark) | 1,002,100 | 90 | 10 | 5.97 | 16.32 | 14.29 |
| 5. Coated Prod. Corp. (Essex Chem. Co.) | 24,043 | 92 | 8 | 5.54 | 21.82 | 16.67 |
| 6. Connecticut Hard Rubber (Armco) | 1,875,314 | 77 | 23 | 6.44 | 14.44 | 25.00 |
| 7. Dennison | 146,887 | 88 | 12 | 5.06 | 10.06 | 12.50 |
| 8. Dymo | 66,217 | 84 | 16 | NA | NA | NA |
| 9. Fitchburg Coated Products (Litton) | 1,182,308 | 73 | 27 | 2.03 | NA | NA |
| 10. Fuller Paste and Adhesive (Fuller H.B.) | 54,710 | 82 | 18 | 3.23 | 15.49 | 14.29 |
| 11. Ideal Tape (Chelsea Ind.) | 73,211 | 58 | 42 | 4.39 | 14.74 | 20.00 |
| 12. Kendall (Colgate Palmolive) | 1,073,893 | 97 | 3 | 6.70 | 15.87 | 14.29 |
| 13. LePage, Inc. (Papercraft) | 80,077 | 77 | 23 | 6.04 | 15.00 | 14.29 |
| 14. Ludlow | 86,670 | 64 | 36 | 3.40 | 5.28 | 5.26 |
| 15. Minnesota Mining & Mfg. | 2,569,296 | 88 | 12 | 4.14 | 18.83 | 9.09 |
| 16. Monarch Marketing (Pitney Bowes) | 246,178 | 80 | 20 | 4.55 | 22.19 | 14.29 |
| 17. Morgan Adhesives (Bemis) | 179,345 | 91 | 9 | 5.77 | 13.50 | 16.67 |
| 18. Mystik Tape (Borden) | 1,241,191 | 83 | 17 | 7.07 | 14.57 | 16.67 |
| 19. Nashua | 131,609 | 77 | 23 | 5.84 | 25.26 | 25.00 |
| 20. Norton Co. | 427,608 | 81 | 19 | 4.57 | 18.58 | 14.29 |
| 21. Norwood (Seton) | 13,428 | 70 | 30 | 3.60 | 28.44 | 25.00 |
| 22. Parmacel (Johnson & Johnson) | 1,480,026 | 100 | 0 | 2.73 | 15.48 | 7.14 |
| 23. Plymouth Rubber | 13,343 | 100 | 0 | NA | NA | NA |
| 24. Rexham Corp. | 54,043 | 100 | 0 | 3.02 | 18.41 | 12.50 |

(con.)

TABLE 8-18 (continued).

| | Firm | Total[c] capital (000$) | Percent equity financed | Percent debt financed | Cost of equity | | |
|---|---|---|---|---|---|---|---|
| | | | | | Dividend method | Gordon-Shapiro method | Solomon method |
| 25. | Scott Graphics<br>S. D. Warren (Scott) | 1,039,341 | 84 | 16 | 5.45 | 13.82 | 16.67 |
| 26. | Sheldahl | 5,123 | 45 | 55 | NA | NA | 20.00 |
| 27. | Tuck (Technical Tape) | 20,849 | 80 | 20 | | | |
| | Weighted mean costs of equity finance (number of firms in calculation) | | | | 4.99<br>n=24 | 15.98<br>n=23 | 14.16<br>n=24 |

[a] List of firms obtained from Table 8.1-4, Section 8.1.1.4.

[b] In some cases financial data represents that for a parent firm. If so, the parent is listed with the subsidiary in parentheses.

[c] Total capital is defined as the sum of outstanding debt and equity. Debt is defined as bonds plus notes (a figure usually less than the financial statement entry of long-term debt). Equity is the net worth of the firm.

where $k_e'$ = dividend method cost of equity capital

$D_0$ = dividend per share common stock

$P_0$ = price per share common stock.

The second method is the growth model which incorporates growth in future earnings to estimate the cost of equity capital. Two growth models were examined. One is the Gordon-Shapiro growth model in which growth is financed out of retained earnings so that the basic cost of equity capital (the dividend price ratio) is increased by the ratio of retained earnings to book value:

$$k_e^2 = \frac{D_0}{P_0} + \frac{E_0 - D_0}{B_0}$$

where $k_e^2$ = Gordon-Shapiro cost of equity capital

$E_0$ = earnings per share common stock

$B_0$ = current book value of stock per share.

Another method of capturing the growth component is given by the Solomon model. The difference between this and the Gordon-Shapiro model is that the denominator of the growth term is the current market value of the firm's stock, $P_0$, rather than the book value:

$$k_e3 = \frac{D_0}{P_0} + \frac{E_0 - D_0}{P_0} = \frac{E_0}{P_0}$$

where $k_e3$ = Solomon cost of equity capital.

While any one of the three cost of capital estimates could be used, the conservative approach would be to use that measure which yields the highest cost of equity capital. This approach is followed in the economic analysis in Section 8.4. For the firms in the sample the Gordon-Shapiro method most often yields the highest cost of equity capital. For 14 of the 22 firms for which data were available, the Gordon-Shapiro estimate is greater than the Solomon estimate. The weighted means, however, are not that different; the Gordon-Shapiro method yields a cost of equity capital of 16.0 percent and the Solomon method 14.2 percent.

8.1.5.2 Outlook. In general the outlook for the pressure sensitive tapes and labels industry is good. Innovation on the supply side and continued growth in demand suggest that sales will continue to grow at roughly the same pace of the last 6 years through 1985.[38]

Supply. The industry has recognized for some time that increased government regulations for pollution control and protection of employee health would create a need for controlling the solvent emissions from solvent-based coating lines. It has only recently been considered an economically strategic move to convert to other technologies such as waterborne adhesive systems and hot melt systems. The reasons for this consideration are: increased cost and availability of energy (solvent systems require a great deal of energy), availability of raw materials necessary for solvent based PSA's, and the advancement of the state-of-the-art of alternate technologies.

The change away from solvent systems has been gradual, but should increase in future years as government emission standards are promulgated, and as energy and raw material prices increase. There will never be a complete move away from solvent-based systems; however, they will no longer dominate the industry.

In 1978 solvent-based adhesives accounted for 85 percent of all coatings.[39] However, it is projected that by 1982 solvent-based coating will account for 55 percent of the market, by 1985 20 percent, and by 1990 only 10 percent.[40,41] Different reports suggest varying projections as to what percentage of which technology will take the lead, but all seem to agree that waterborne coatings and hot melt systems will account for the bulk of the production.

As has been the case historically, it is expected that increased supply will result from existing plant expansion rather than new firm entry.[42]

Demand. Projected growth of pressure sensitive tapes and labels is shown in Figure 8-4.[43,44] Overall growth of pressure sensitive tapes and labels sales are expected to continue up through 1985. The growth of the labels market is expected to continue at a rate in excess of that

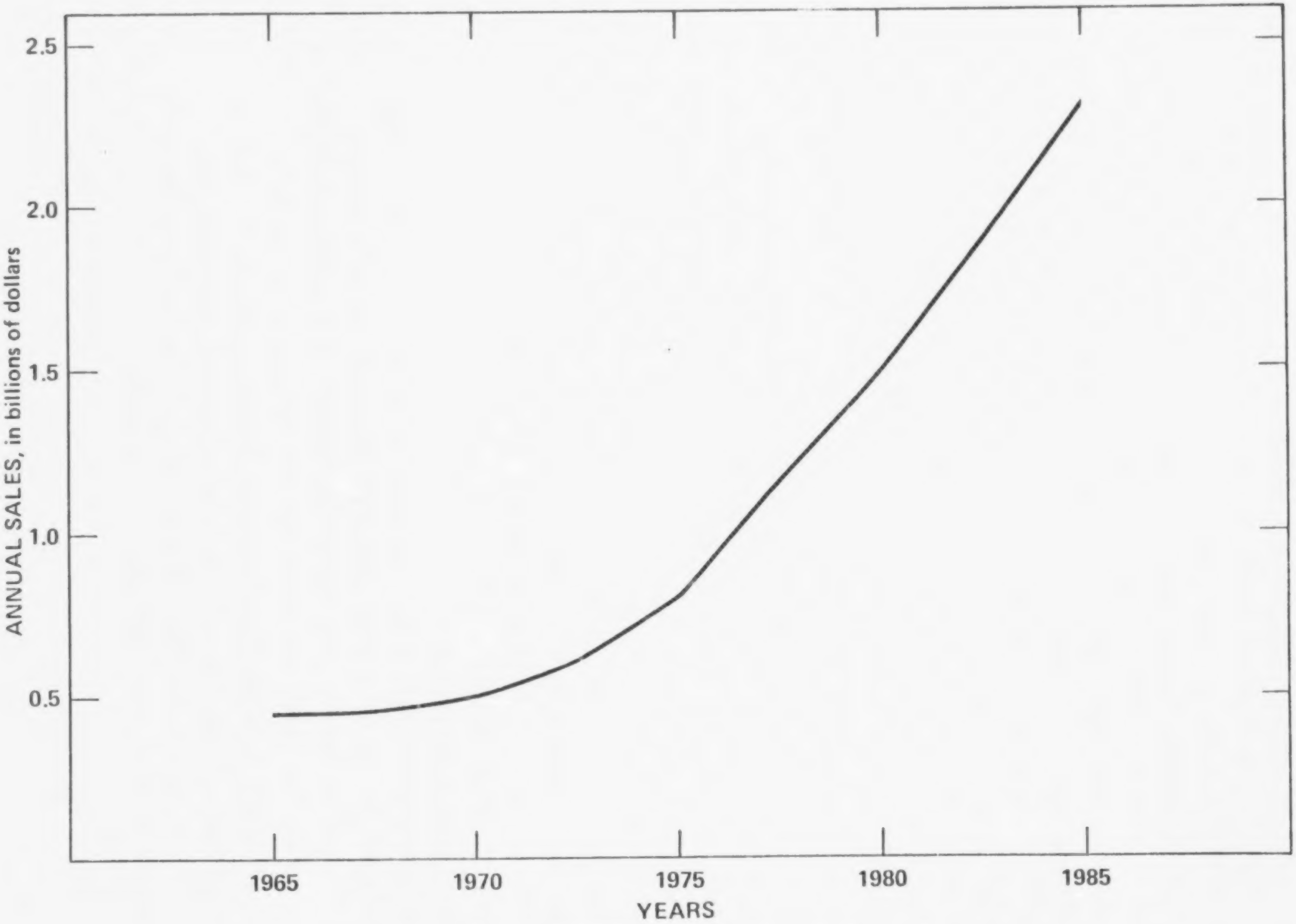

Figure 8-4. Estimated annual sales of pressure sensitive tapes and labels (excluding printed labels)

for tape until about 1981, and then it will taper back to about the same growth rate as the more mature tapes market.[45]

Growth of the pressure sensitive labels market may come at the expense of the gummed products industry. The replacement of water activated and heat activated labels systems with pressure sensitive labels is especially advantageous for production involving short runs. The pressure sensitive labels market has increased at 10-15 percent per year in contrast to 6-7 percent per year for the label industry as a whole.[46] Pressure sensitive tapes will be used in more items as fasteners and pressure sensitive labels will be used more on glass bottles, metal cans, and other commercial containers. It is estimated that by 1982 about 25 percent of all such containers will have pressure sensitive labels.[47]

## 8.2 COST ANALYSIS OF REGULATORY ALTERNATIVES

This section analyzes three regulatory alternatives which were developed in Chapter 6: (I) the recommended CTG limits, (II) oven emissions control, and (III) oven and fugitive emissions control. Each of these levels are defined in later paragraphs. The regulatory alternatives are applied to the new facility model plants (Chapter 6) and then are costed for installed capital and operating costs. A cost effectiveness analysis is presented for the added levels of control. A short discussion is also given on the capital and operating costs of modified or reconstructed facilities.

### Regulatory Alternative I

When developing regulations for their implementation plans, states generally follow the guidelines documents issued by the U.S. Environmental Protection Agency. The guideline document that covers coating of pressure sensitive tapes and labels is entitled Control of Volatile Organic Emissions from Existing Stationary Sources - Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles, and Light-Duty Trucks.[48] The coating of pressure sensitive tapes and labels comes under the heading of paper coating. The recommended EPA limit is:

| Affected Facility | Recommended Limitation | |
|---|---|---|
| | kg per liter of coating (minus water) | lbs. per gal. of coating (minus water) |
| Coating Line | 0.35 | 2.9 |

The EPA Guideline goes on to say that "these levels are for all coatings put on paper, pressure sensitive tapes regardless of substrate (including paper, fabric, or plastic film) and related web coating processes on plastic film such as typewriter ribbons, photographic film, and magnetic tape". States such as Ohio, Illinois, Massachusetts and Pennsylvania are currently developing a regulation for coating operations which follows this guideline. (California is the only state which is proposing their own rule for VOC emissions from coating facilities).[49]

The model plants shown in Chapter 6 use an adhesive mixture which is 33.3 weight percent solids and 66.7 weight percent solvent. If one assumes: (1) the solvent has a specific gravity of 0.863, (2) the coating formulation has a specific gravity of 0.935, and (3) the control device is down five percent of the time that the coating line is operating (conservative estimate); the required solvent removal to meet the CTG recommendation is 78.3 percent of the solvent in the formulation (including water). The CTG control level is used as the baseline for comparisons done in this chapter, and represents the most likely level of control for adhesive, release, and precoat coating lines if no national New Source Performance Standards were developed.

### Regulatory Alternative II

Regulatory Alternative II is defined in this study as control of oven emissions only. In this situation, the coater is making no attempt to recover fugitive emissions from around the coating area or oven exit. In the adhesive and release model plants, the level of control varies with the size of the unit because it is assumed that line speed and line size have effects on the amount of fugitive emissions.[50] The level of VOC emission reduction which represents moderate control is estimated at 86.4 percent for large, fast lines; 82.5 percent for medium lines/ and 80.8 percent for slower, small lines. All of these levels of control are based on a 96 percent VOC emission reduction across the control device.

Regulatory Alternative III

Regulatory Alternative III is defined as capture and removal of oven off gas and collectible fugitive emissions. This represents the best available control technology. For this study it is assumed that most fugitive emissions are generated in the area from the coater to the oven entrance. It is also assumed that a hood is used over this area to capture the emissions. For the carbon adsorption model facilities, the hood gases are ducted to the oven furnaces. For the incineration model, the hood gases are ducted to the secondary heat exchangers where they are used for makeup air to the ovens. For the medium and small coating lines, the hood gases exactly make up the air requirements for the ovens. The estimated overall VOC reduction for model facilities under this regulatory alternative is 90 percent. A summary of the required VOC control levels for Regulatory Alternatives I, II, and III is given in Table 8-19.

### 8.2.1 New Facilities

Table 8-20 outlines all of the adhesive and silicone coater model plants that are examined in the cost analysis. Basically, two control technologies (carbon adsorption and incineration) are examined at three different control levels on three different line sizes (production rates). For comparative purposes, waterborne and 100 percent solids technologies were costed out in this analysis. Table 8-21 summarizes the model plants developed for these alternative coating technologies. A more detailed description of the model plants is given in Chapter 6.

#### 8.2.1.1 Installed Capital and Annualized Costs

The costs presented in this section are based on an order-of-magnitude estimate. The probable accuracy of the absolute cost values is ± 30 percent. The results are used more as a comparative basis to document the economics which may face a coater if a regulation goes into effect.

Table 8-22 lists the assumptions used in calculating the capital and operating costs of a "typical" coating facility. The raw material

TABLE 8-19. SUMMARY OF VOC CONTROL LEVELS FOR REGULATORY ALTERNATIVES I, II, and III

| Model Plant Size (line width, line speed) | Required Overall VOC Control Level | | |
|---|---|---|---|
| | Alternative I | Alternative II | Alternative III |
| Small<br>(0.61m, 0.13 m/sec) | 78.3 | 85 | 90 |
| Medium<br>(0.9m, 0.3 m/sec) | 78.3 | 85 | 90 |
| Large<br>(1.5m, 1.2 m/sec) | 78.3 | 86 | 90 |

TABLE 8-20. MODEL CASES FOR COST ANALYSIS

| Cases | Line Width Meters (inches) | Line Speed[a] m/sec(fpm) | Annual Production $X10^6 m^2 (X10^6 yd^2)$ | Solvent | Control Device[b] | Control Efficiencies | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | Control Device | Overall Adhesive | Overall Silicone |
| 1/19 | 0.61(24) | 0.13(25) | 1.7(2.0) | Toluene | CA | 96 | 78.8 | 78.8 |
| 2/20 | 0.61(24) | 0.13(25) | 1.7(2.0) | Toluene | CA | 96 | 84.5 | 85 |
| 3/21 | 0.61(24) | 0.13(25) | 1.7(2.0) | Toluene | CA | 96 | 90 | 89 |
| 4/22 | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Toluene | CA | 96 | 78.3 | 78.4 |
| 5/23 | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Toluene | CA | 96 | 85 | 85 |
| 6/24 | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Toluene | CA | 96 | 90 | 90.1 |
| 7/25 | 1.5 (60) | 1.2(230) | 39(46) | Toluene | CA | 96 | 78.1 | 78.1 |
| 8/26 | 1.5 (60) | 1.2(230) | 39(46) | Toluene | CA | 96 | 85.2 | 85 |
| 9/27 | 1.5 (60) | 1.2(230) | 39(46) | Toluene | CA | 96 | 90 | 90 |
| 10/28 | 0.61(24) | 0.13(25) | 1.7(20) | Naphtha | Inc | 96 | 78.3 | 79.1 |
| 11/29 | 0.61(24) | 0.13(25) | 1.7(20) | Naphtha | Inc | 96 | 85 | 85.1 |
| 12/30 | 0.61(24) | 0.13(25) | 1.7(20) | Naphtha | Inc | 96 | 90 | 89.1 |
| 13/31 | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Naphtha | Inc | 96 | 78.2 | 78.6 |
| 14/32 | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Naphtha | Inc | 96 | 83.5 | 85 |
| 15/33 | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Naphtha | Inc | 96 | 89 | 90.3 |
| 16/34 | 1.5 (60) | 1.2(230) | 39(46) | Naphtha | Inc | 96 | 78.4 | 78.3 |
| 17/35 | 1.5 (60) | 1.2(230) | 39(46) | Naphtha | Inc | 96 | 85 | 85.1 |
| 18/36 | 1.5 (60) | 1.2(230) | 39(46) | Naphtha | Inc | 96 | 90.1 | 90 |

[a] Represents average line speed, includes idle periods for changing product, clean-up and maintenance.

[b] CA = Carbon adsorption; Inc = Incineration with primary and secondary heat recovery;
Adhesive cases = 1-18; Silicone release cases = 19-36

TABLE 8-21. LOW-SOLVENT MODEL CASES FOR COST ANALYSIS

| Case | Line Width Meters (inches) | Line Speed m/sec (fpm) | Annual Production $X10^6 m^2 (X10^6 yd^2)$ | Solvent | Control Efficiencies Overall Adhesive | Control Efficiencies Overall Silicone |
|---|---|---|---|---|---|---|
| 37. | 0.61 (24) | 0.13(25) | 1.7(2.0) | Water | 100 | --- |
| 38. | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Water | 100 | --- |
| 39. | 1.5 (60) | 1.3(230) | 39(46) | Water | 100 | --- |
| 40. | 0.61 (24) | 0.13(25) | 1.7(2.0) | Water | --- | 100 |
| 41. | 0.9 (36) | 0.3 (53) | 5.4(6.4) | Water | --- | 100 |
| 42. | 1.5 (60) | 1.2(230) | 39(46) | Water | --- | 100 |
| 43. | 0.61 (24) | 0.13(35) | 1.7(2.0) | none | 100 | --- |
| 44. | 0.9 (36) | 0.3 (53) | 5.4(6.4) | none | 100 | --- |
| 45. | 1.5 (60) | 1.2(230) | 39(46) | none | 100 | --- |
| 46. | 0.61 (24) | 0.13(25) | 1.7(2.0) | none | --- | 100 |
| 47. | 0.9 (36) | 0.3 (53) | 5.4(6.4) | none | --- | 100 |
| 48. | 1.5 (60) | 1.2(230) | 39(46) | none | --- | 100 |

Waterborne technology : Cases 37-42.

Hot melt technology for adhesive coating lines: Cases 43-45.

100 percent solids technology for silicone release coating lines: Cases 46-48.

## TABLE 8-22. ASSUMPTIONS USED IN COST ANALYSIS

The following assumptions are used in the cost analysis:

1. Plant operates 6000 hr/year.
2. The adhesive formulation is 66.7 wt% and 33.3 wt% adhesive. The specific gravity of the formulation is 0.935 and the solvent is 0.863. The silicone formulation is 95 wt% solvent and 5 wt% silicone. The specific gravity of the formulation is 0.870 and the silicone is 1.0.
3. Adhesive weight on web equals 0.094 $lb/yd^2$, the silicone weight is 0.0015 $lb/yd^2$.
4. The ovens operate at 25% LEL.
5. The oven burners use natural gas priced at $3.00/$10^6$ Btu.
6. Operating labor costs are $10/hr/man.
7. Electricity costs are $0. 05/kwhr
8. Cooling water is $0.50/ 1000 gallons
9. Steam for the carbon adsorption unit is supplied by a low pressure (15 psig) boiler.
10. The carbon adsorber, steam-use rate is 4 lbs. of steam per pound of solvent recovered.
11. The primary and secondary heat recovery systems capture 35% of the heat from the incinerator for the SIP and moderate control cases and 47% from the stringent control case.
12. Toluene cost is $1.25/gallon and naphtha cost is $0.75/gallon.
13. Naphtha supplies 128,000 Btu/gallon (or 6590 Btu/SCF).
14. Indirect capital costs include engineering and start-up costs. They are estimated at 10% of the total installed equipment costs.
15. Contingency is estimated at 10% of the total installed equipment costs.
16. Maintenance labor is 4 percent of the process capital.
17. Maintenance materials are 2 percent of the process capital.
18. Interest is 12 percent.
19. Working capital is not estimated for this study.
20. Carbon adsorption unit and incineration unit are 96% efficient.
21. Activated carbon is $1.00/lb and the bed is replaced every two years.
22. Fuel oil cost is $0.80/gallon (No. 2 Fuel Oil).

TABLE 8-22 (continued). ASSUMPTIONS USED IN COST ANALYSIS

23. The following raw material costs are used:
    a. solvent-based adhesive resin - $0.70/lb (without solvent)
    b. hot melt resin - $0.80/lb
    c. acrylic waterborne resin - $0.85/lb (formulated)
    d. prerelease-coated paper web - $0.10/sq. yd.
    e. silicone release - $3.50/lb
    f. uncoated paper web - $0.06/sq. yd.
24. The incinerator pilot flames are fired on natural gas. About 20 scfh is required for this operation.
25. The capital charge rate is estimated at 21.7 percent of the total capital investment. This assumes the capital is recovered at 12 percent interest over 10 years. The total of general and administrative costs, taxes, and insurance are estimated at 4 percent of the total capital investment.
26. Plant overhead is estimated at 50 percent of the operating labor, supervision, and maintenance labor.
27. Administrative overhead is estimated at 50 percent of the operating labor.
28. Building use fee is estimated at $116,000/year for the large coating line and $87,000/year for the medium and small coating lines.
29. Equipment is depreciated by straight-line depreciation over ten years.
30. Labor to operate control equipment is estimated at one-half man per shift. Maintenance labor is based on a percent of the capital investment (see item 16).

costs are meant to represent mid-1979 costs although they may in some cases be high. Raw material, utility, labor and equipment costs are highly dependent on location. A detailed study of these variations will not be presented in this report.

The capital costs for the coating lines (without control equipment) are based on an average of vendor and manufacturer sources.[51,52,53,54,55,56,57,58,59] The cost of a coating line is highly dependent on the degree of automation and line speed. A 1.5 meter (60 inch) to 2.0 meter (80-inch) coating line can cost from $400,000 to $2,500,000 installed. High cost items are the oven, the coater, the unwind/wind equipment and the beta gauge controls.

The installed capital cost of the 1.5 meter (60-inch) solvent-based model plant coating system is estimated at $1.7 million. The installed capital costs of the 1.2 meter (48-inch) and the 0.9 meter (36-inch) model plant coating lines are estimated at $1,250,000 and $980,000, respectively. All costs for this study are mid-1979 dollars and are expected to reflect installed costs for average facilities.

The waterborne coating facility is estimated to cost about the same as a solvent-based coating system. Waterborne systems use coaters and unwind/wind equipment nearly indentical to the solvent-based system's.

The hot melt system is expected to cost less than a solvent-based or waterborne system.[61] The reduced capital cost primarily comes from the absence of a drying oven in a hot melt coating system. The reduced cost resulting from not having a drying oven may be partially offset by more expensive adhesive feeding equipment. The hot melt is usually fed through a slot die extruder. As mentioned in Chapter 3, the performance of present day hot melt adhesives is limited. Hot melt adhesives are not good in terms of strength, heat resistance, and environmental stress. To eliminate these problems researchers are examining the use of crosslinking agents with the hot melt. The crosslinking reactions are caused to occur through electron beam or UV radiation of the material. The cost of this added irradiation equipment is estimated at $500,000 for a full scale unit.

The capital costs for the carbon adsorption and incineration control equipment are derived from industry and vendor data and EPA reports. Figures 8-5 and 8-6 show the installed capital costs used in this study for carbon adsorption units and incineration units, respectively. Estimation of smaller sized units (less than 10,000 acfm) required extrapolation of the data into regions where very little, if any, data existed.

Industry cost data for carbon adsorption units tended to be higher than the vendor or EPA estimates. The industry data is felt to be a better estimate of the actual new installed costs. Therefore, the cost curve is drawn to represent more of the industry data than the vendor or EPA data. The cost curve for incineration units with primary and secondary heat exchangers is based on two EPA studies and a single industry data point. Very few existing incineration systems on pressure sensitive tapes and labels coating lines use more than primary heat recovery systems.

The capital costs for the hood and hood ducting are estimated from an EPA study done by GARD, Inc.[62] The hood's estimated dimensions are five feet long and as wide as the web width. The ducting for the carbon adsorption system is estimated to be 30 feet long with 3 bends and one damper. The incinerator hood ducting is estimated to be 75 feet long with 4 bends and one damper. The hood duct of the incinerator-controlled line is longer because it is assumed that the incinerator and secondary heat exchanger are located outside the building. Each ducting system is equipped with one fan.

#### 8.2.1.2 Cost Analysis and Cost Effectiveness

The costs in Tables 8-23, 8-24, and 8-25 represent three different types of VOC control. The model plant numbers across the top of each table correspond to the model plants outlined in Tables 8-20 and 8-21. These numbers also correspond with all model plant numbers given in Chapter 6. The calculated installed capital and annualized costs of the carbon adsorption-controlled coating facilities are presented in Table 8-23. Model plant numbers 1 through 9 represent adhesive coating

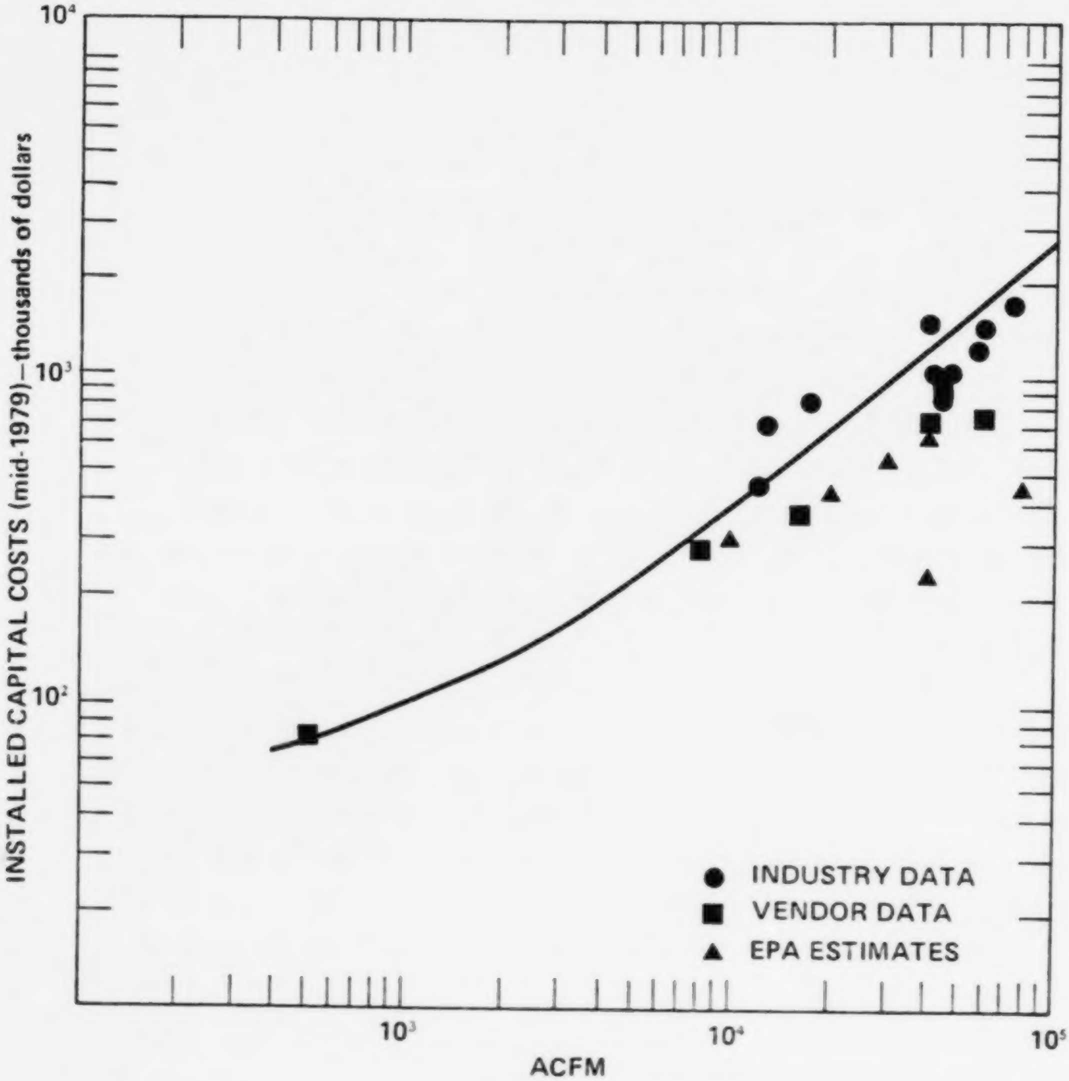

Figure 8-5. Estimated installed capital costs for carbon adsorption units.

References for Figure 8-5.

Industry data—60,61,62,63,64,65,66,67,68,69,70
Vendor data—71,72
EPA estimates—73,74

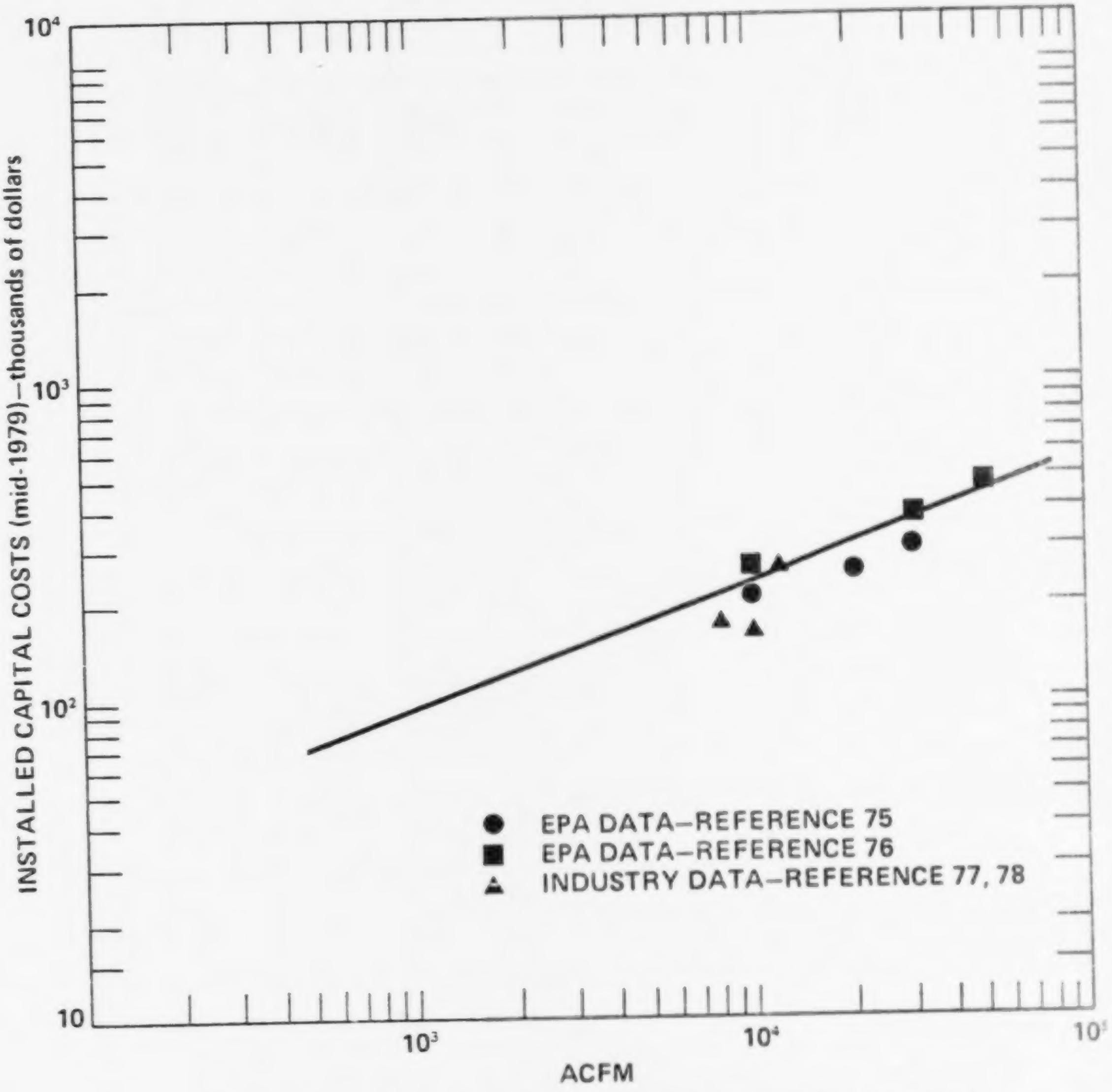

Figure 8-6. Estimated installed capital costs for incineration system with primary and secondary heat recovery.

## TABLE 8-23. ESTIMATED INSTALLED CAPITAL AND ANNUALIZED COSTS FOR CARBON ADSORPTION-CONTROLLED MODEL FACILITIES
(basis: thousands of mid-1979 dollars)

| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Installed capital costs | | | | | | | | | |
| Coater | 980 | 980 | 980 | 1250 | 1250 | 1250 | 1700 | 1700 | 1700 |
| Control device | 100 | 101 | 103 | 186 | 190 | 195 | 800 | 1000 | 1020 |
| Hooding | 0 | 0 | 4 | 0 | 0 | 6 | 0 | 0 | 23 |
| Indirects[a] | 216 | 216 | 218 | 287 | 288 | 290 | 500 | 540 | 549 |
| Total Installed Capital Costs | 1296 | 1297 | 1305 | 1723 | 1728 | 1741 | 3000 | 3240 | 3292 |
| Annualized Costs | | | | | | | | | |
| Raw materials[b] | 397 | 397 | 397 | 1270 | 1270 | 1270 | 9124 | 9124 | 9124 |
| Operating and Supervision labor | 180 | 180 | 180 | 240 | 240 | 240 | 300 | 300 | 300 |
| Coater utilities | 46 | 47 | 47 | 73 | 73 | 73 | 142 | 148 | 150 |
| Control device utilities | 17 | 18 | 20 | 55 | 59 | 59 | 377 | 415 | 435 |
| Credit for solvent or heat recovery | (52) | (56) | (59) | (163) | (176) | (176) | (1186) | (1310) | (1369) |
| Maintenance-labor and materials | 65 | 65 | 65 | 86 | 87 | 87 | 150 | 162 | 165 |
| Indirects[c] | 540 | 540 | 542 | 700 | 701 | 704 | 1087 | 1143 | 1155 |
| Total Annual Operating Costs | 1193 | 1191 | 1192 | 2261 | 2254 | 2257 | 9994 | 9982 | 9960 |
| dollars/sq meter | .713 | .712 | .713 | .425 | .424 | .424 | .260 | .260 | .259 |
| dollars/sq yard | .597 | .596 | .596 | .356 | .354 | .355 | .217 | .217 | .217 |
| Annual Operating Cost of Control Equipment[d] | 65.10 | 62.48 | 62.36 | 22.86 | 15.36 | 17.16 | (455.6) | (471.6) | (504.0) |
| dollars/sq meter | .0389 | .0374 | .0372 | .0043 | .0029 | .0032 | (.0118) | (.0123) | (.0131) |
| dollars/sq yard | .0326 | .0312 | .0311 | .0036 | .0024 | .0027 | (.0099) | (.0103) | (.0110) |

(    ) indicates credit instead of cost.

TABLE 8-23 (continued). ESTIMATED INSTALLED CAPITAL AND ANNUALIZED COSTS FOR CARBON ADSORPTION-CONTROLLED MODEL FACILITIES
(basis: thousands of mid-1979 dollars)

| | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 |
|---|---|---|---|---|---|---|---|---|---|
| Installed capital costs | | | | | | | | | |
| Coater | 580 | 580 | 580 | 740 | 740 | 740 | 1000 | 1000 | 1000 |
| Control device | 54 | 55 | 56 | 74 | 75 | 77 | 198 | 210 | 220 |
| Hooding | 0 | 0 | 3 | 0 | 0 | 4 | 0 | 0 | 7 |
| Indirects[a] | 127 | 127 | 128 | 163 | 163 | 164 | 240 | 242 | 245 |
| Total Installed Capital Costs | 761 | 762 | 767 | 977 | 978 | 985 | 1438 | 1452 | 1472 |
| Annualized Costs | | | | | | | | | |
| Raw materials[b] | 141 | 141 | 141 | 450 | 450 | 450 | 3230 | 3230 | 3230 |
| Operating and Supervision labor | 180 | 180 | 180 | 240 | 240 | 240 | 300 | 300 | 300 |
| Coater utilities | 44 | 44 | 44 | 66 | 66 | 66 | 94 | 95 | 96 |
| Control device utilities | 4 | 4 | 4 | 9 | 9 | 10 | 66 | 71 | 75 |
| Credit for solvent or heat recovery | (8) | (8) | (8) | (25) | (27) | (28) | (177) | (192) | (203) |
| Maintenance-labor and materials | 38 | 38 | 39 | 49 | 49 | 49 | 72 | 72 | 74 |
| Indirects[c] | 413 | 415 | 416 | 525 | 525 | 527 | 722 | 725 | 729 |
| Total Annual Operating Costs | 814 | 814 | 815 | 1314 | 1312 | 1314 | 4307 | 4301 | 4301 |
| dollars/sq meter | .487 | .487 | .487 | .247 | .247 | .247 | .112 | .112 | .112 |
| dollars/sq yard | .407 | .407 | .408 | .207 | .206 | .207 | .094 | .094 | .094 |
| Annual Operating Cost of Control Equipment[d] | 55.10 | 81.16 | 80.57 | 75.62 | 74.04 | 74.83 | 31.63 | 26.42 | 23.27 |
| dollars/sq meter | .0450 | .0485 | .0482 | .0142 | .0139 | .0141 | .0008 | .0007 | .0006 |
| dollars/sq yard | .0384 | .0406 | .0403 | .0119 | .0116 | .0118 | .0007 | .0006 | .0005 |

( ) indicates credit instead of cost.

TABLE 8-23 (continued). ESTIMATED INSTALLED CAPITAL AND ANNUALIZED COSTS FOR CARBON ADSORPTION-CONTROLLED MODEL FACILITIES
(basis: thousands of mid-1979 dollars)

[a] Includes a charge for startup and engineering (10% of the coater and control device capital cost) and a charge for contingency (10% of the coater and control device capital cost). It does not include working capital.

[b] Includes a release-coated web, formulated adhesive, and solvent (if necessary).

[c] Includes a capital charge (21.7% of total capital cost), an overhead charge, and a building use charge.

[d] Includes credits for solvent recovery.

TABLE 8-24. ESTIMATED INSTALLED CAPITAL AND ANNUALIZED COSTS FOR INCINERATION-CONTROLLED MODEL FACILITIES
(basis: thousands of mid-1979 dollars)

| | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|
| Installed capital costs | | | | | | | | | |
| Coater | 980 | 980 | 980 | 1250 | 1250 | 1250 | 1700 | 1700 | 1700 |
| Control device | 126 | 130 | 133 | 198 | 202 | 202 | 430 | 445 | 450 |
| Hooding | 0 | 0 | 5 | 0 | 0 | 8 | 0 | 0 | 40 |
| Indirects[a] | 221 | 222 | 224 | 290 | 290 | 292 | 426 | 427 | 438 |
| Total Installed Capital Costs | 1327 | 1332 | 1342 | 1738 | 1742 | 1752 | 2556 | 2574 | 2623 |
| Annualized Costs | | | | | | | | | |
| Raw materials[b] | 371 | 371 | 371 | 1186 | 1186 | 1186 | 8524 | 8524 | 8524 |
| Operating and Supervision labor | 180 | 180 | 180 | 240 | 240 | 240 | 300 | 300 | 300 |
| Coater utilities | 78 | 79 | 81 | 172 | 178 | 184 | 869 | 952 | 987 |
| Control device utilities | 14 | 14 | 15 | 42 | 44 | 46 | 291 | 322 | 335 |
| Credit for solvent or heat recovery | (34) | (35) | (37) | (107) | (113) | (119) | (783) | (866) | (901) |
| Maintenance-labor and materials | 66 | 66 | 67 | 87 | 87 | 87 | 128 | 129 | 132 |
| Indirects[c] | 547 | 548 | 551 | 703 | 704 | 706 | 983 | 988 | 1000 |
| Total Annual Operating Costs | 1222 | 1223 | 1228 | 2323 | 2326 | 2330 | 10312 | 10349 | 10377 |
| dollars/sq meter | .731 | .731 | .734 | .437 | .437 | .438 | .268 | .269 | .270 |
| dollars/sq yard | .611 | .612 | .614 | .365 | .366 | .366 | .224 | .225 | .226 |
| Annual Operating Cost of Control Equipment[d] | 90.28 | 90.84 | 90.97 | 70.35 | 67.81 | 63.76 | (270.8) | (317.4) | (338.0) |
| dollars/sq meter | .0540 | .0543 | .0544 | .0132 | .0128 | .0120 | (.0070) | (.0083) | (.0088) |
| dollars/sq yard | .0451 | .0454 | .0455 | .0111 | .0107 | .0100 | (.0059) | (.0069) | (.0073) |

(  ) indicates credit instead of cost.

TABLE 8-24 (cont.). ESTIMATED INSTALLED CAPITAL AND ANNUALIZED COSTS FOR INCINERATION-CONTROLLED MODEL FACILITIES
(basis: thousands of mid-1979 dollars)

| | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 |
|---|---|---|---|---|---|---|---|---|---|
| Installed capital costs | | | | | | | | | |
| Coater | 580 | 580 | 580 | 740 | 740 | 740 | 1000 | 1000 | 1000 |
| Control device | 60 | 62 | 63 | 95 | 97 | 100 | 204 | 210 | 217 |
| Hooding | 0 | 0 | 3 | 0 | 0 | 4 | 0 | 0 | 9 |
| Indirects[a] | 128 | 128 | 129 | 167 | 167 | 169 | 241 | 242 | 245 |
| Total Installed Capital Costs | 768 | 770 | 775 | 1002 | 1004 | 1013 | 1445 | 1492 | 1471 |
| Annualized Costs | | | | | | | | | |
| Raw materials[b] | 137 | 137 | 137 | 437 | 437 | 437 | 3139 | 3139 | 3139 |
| Operating and Supervision labor | 180 | 180 | 180 | 240 | 240 | 240 | 300 | 300 | 300 |
| Coater utilities | 49 | 50 | 50 | 82 | 83 | 83 | 203 | 213 | 220 |
| Control device utilities | 3 | 3 | 3 | 6 | 7 | 7 | 45 | 48 | 51 |
| Credit for solvent or heat recovery | (5) | (6) | (6) | (17) | (18) | (18) | (117) | (127) | (134) |
| Maintenance-labor and materials | 39 | 39 | 39 | 50 | 50 | 51 | 72 | 72 | 74 |
| Indirects[c] | 417 | 417 | 418 | 531 | 532 | 534 | 724 | 725 | 729 |
| Total Annual Operating Costs | 820 | 820 | 821 | 1329 | 1331 | 1334 | 4366 | 4370 | 4379 |
| dollars/sq meter | .490 | .490 | .491 | .250 | .250 | .251 | .114 | .114 | .114 |
| dollars/sq yard | .410 | .410 | .411 | .209 | .209 | .210 | .095 | .095 | .095 |
| Annual Operating Cost of Control Equipment[d] | 85.37 | 85.26 | 85.67 | 89.34 | 90.15 | 91.35 | 73.02 | 68.42 | 67.05 |
| dollars/sq meter | .0510 | .0510 | .0512 | .0168 | .0170 | .0172 | .0019 | .0018 | .0017 |
| dollars/sq yard | .0427 | .0426 | .0428 | .0140 | .0142 | .0144 | .0016 | .0015 | .0015 |

( ) indicates credit instead of costs.

## TABLE 8-24 (cont.). ESTIMATED INSTALLED CAPITAL AND ANNUALIZED COSTS FOR INCINERATION -CONTROLLED MODEL FACILITIES
(basis: thousands of mid-1979 dollars)

[a] Includes a charge for startup and engineering (10% of the coater and control device capital cost) and a charge for contingency (10% of the coater and control device capital cost). It does not include working capital.

[b] Includes a release-coated web, formulated adhesive, and solvent (if necessary).

[c] Includes a capital charge (21.7% of total capital cost), an overhead charge, and a building use charge.

[d] Includes credits for heat recovery.

TABLE 8-25. ESTIMATED INSTALLED CAPITAL AND ANNUALIZED COSTS OF LOW-SOLVENT MODEL FACILITIES

(basis: thousands of mid-1979 dollars)

|  | 37 | 38 | 39 | 40 | 41 | 42 |
|---|---|---|---|---|---|---|
| Installed capital costs |  |  |  |  |  |  |
| Coater | 980 | 1250 | 1700 | 580 | 740 | 1000 |
| Control device | 0 | 0 | 0 | 0 | 0 | 0 |
| Hooding | 0 | 0 | 0 | 0 | 0 | 0 |
| Indirects[a] | 196 | 250 | 340 | 116 | 148 | 200 |
| Total Installed Capital Costs | 1176 | 1500 | 2040 | 696 | 888 | 1200 |
| Annualized Costs |  |  |  |  |  |  |
| Raw materials[b] | 360 | 1152 | 8272 | 131 | 418 | 3002 |
| Operating and Supervision labor | 180 | 240 | 300 | 180 | 240 | 300 |
| Coater utilities | 4 | 12 | 89 | 38 | 56 | 78 |
| Control device utilities | 0 | 0 | 0 | 0 | 0 | 0 |
| Credit for solvent or heat recovery | 0 | 0 | 0 | 0 | 0 | 0 |
| Maintenance-labor and materials | 59 | 75 | 102 | 35 | 45 | 60 |
| Indirects[c] | 514 | 650 | 880 | 402 | 507 | 666 |
| Total Annual Operating Costs | 1117 | 2129 | 9652 | 786 | 1266 | 4106 |
| dollars/sq meter | 0.669 | 0.394 | 0.247 | 0.471 | 0.234 | 0.105 |
| dollars/sq yard | 0.558 | 0.333 | 0.210 | 0.393 | 0.198 | 0.089 |

TABLE 8-25 (cont.). ESTIAMTED INSTALLED CAPITAL AND ANNUALIZED COSTS OF LOW-SOLVENT MODEL FACILITIES
(basis: thousands of mid-1979 dollars)

| | 43 | 44 | 45 | 46 | 47 | 48 |
|---|---|---|---|---|---|---|
| Installed capital costs | | | | | | |
| Coater | 577 | 735 | 1000 | 450 | 575 | 780 |
| Control device | 0 | 0 | 0 | 0 | 0 | 0 |
| Hooding | 0 | 0 | 0 | 0 | 0 | 0 |
| Indirects[a] | 116 | 148 | 200 | 90 | 116 | 156 |
| Total Installed Capital Costs | 693 | 883 | 1200 | 540 | 691 | 936 |
| Annualized Costs | | | | | | |
| Raw materials[b] | 350 | 1122 | 8056 | 131 | 418 | 3002 |
| Operating and Supervision labor | 180 | 180 | 240 | 180 | 240 | 240 |
| Coater utilities | 1 | 3 | 26 | 38 | 56 | 78 |
| Control device utilities | 0 | 0 | 0 | 0 | 0 | 0 |
| Credit for solvent or heat recovery | 0 | 0 | 0 | 0 | 0 | 0 |
| Maintenance-labor and materials | 45 | 44 | 60 | 27 | 35 | 47 |
| Indirects[c] | 401 | 446 | 616 | 365 | 461 | 518 |
| Total Annual Operating Costs | 967 | 1795 | 8998 | 741 | 1210 | 3885 |
| dollars/sq meter | 0.579 | 0.332 | 0.231 | 0.443 | 0.224 | 0.0996 |
| dollars/sq yard | 0.483 | 0.280 | 0.196 | 0.370 | 0.189 | 0.0845 |

[a] Includes a charge for startup and engineering (10% of the coater and control device capital cost) and a charge for contingency (10% of the coater and control device capital cost). It does not include working capital.

[b] Includes web, formulated silicone, and solvent (if necessary).

[c] Includes a capital charge (21.7% of total capital cost), an overhead charge, and a building use charge.

lines and numbers 19 through 27 are silicone release lines. Table 8-24 presents the capital and annualized costs for incineration-controlled facilities. Model plant numbers 10 through 18 represent adhesive facilities and 28 through 36 silicone release facilities. The capital and annualized costs for the low-solvent coating facilities are given in Table 8-25. The following coating lines are represented by the model plant numbers in this table: 37 through 39 are waterborne adhesives, 40 through 42 are waterborne releases, 43 through 45 are 100 percent solids adhesives, and 46 through 48 are 100 percent solids releases.

An examination of these costs produces the following general conclusions:

(1) The installed capital costs for a carbon adsorption system become increasingly greater than an incineration system as the size of the unit increases.

(2) The annualized costs for large coating facilities are dominated by the raw materials costs. In small units labor and indirect costs also become major factors.

(3) Even with the large credit for recovered solvent, the annualized cost of a carbon adsorption-controlled coating facility is comparable to a facility with an incineration system. The major equalizing forces are the large fuel charge for the steam generator, the higher annualized costs (i.e., capital charge rate and maintenance) due to the higher capital costs for the carbon adsorption system, and the less expensive solvent used in incineration models.

(4) The hot melt system appears to have a definite capital cost advantage over a system that coats solvent or waterborne adhesives. However, the expected higher raw material costs make the final product costs comparable to the solvent-based systems.

(5) The higher costs of acrylic formulations make them less attractive to comparable solvent-based or hot melt rubber/resin formulations. These cost differences may

diminish if coating is done on smaller coaters where labor and indirect charges become more of a factor.

(6) The operating (both direct and indirect) costs for the control equipment represent approximately 1 to 7 percent of the annualized costs in adhesive coating systems and 1 to 10 percent in the silicone coating systems.

(7) The capital cost for the hood and ducting system is small in comparison to the total capital cost of the coater and control device.

The line speed of the coating equipment has a large effect on the overall economics. Line speeds vary from a few feet per minute to 1,000 feet per minute for new latex and hot melt coaters.[79,80] The higher line speeds mean a higher percentage of the operating costs are associated with the raw material. Therefore, the percentage of operating costs attributable to control equipment is lower. Also, higher line speeds make smaller, less capital intensive equipment more attractive. One industry source indicates that while there is an economy of scale from 60-inch width hot melt coaters, most organizations will evaluate hot melt machinery in the 30-inch width range.[81]

The cost effectiveness of the control units in the model plants can be estimated by comparing the operating costs associated with the control device to the amount of solvent recovered or destroyed. The control costs include the control device utilities and operating labor and the maintenance and indirect costs associated with the control device. Table 8-26 shows the calculated cost-effectiveness values for the adhesive and release model plants controlled by carbon adsorption with and without credits for solvent recovery. The same cost-effectiveness analysis for the incineration-controlled model plants is given in Table 8-27. Without credits, the control of solvent emissions results in an operational charge for all model facilities.

When credits are given for the recovered solvent or heat, the situation turns completely around. For carbon adsorption systems, the recovered solvent is credited at the price of the solvent (for toluene it would be $1.25 per gallon). For the incineration systems, credit is

### TABLE 8-26. ESTIMATED COST-EFFECTIVENESS OF CARBON ADSORPTION CONTROL DEVICES ON MODEL FACILITIES (WITH AND WITHOUT SOLVENT RECOVERY CREDITS)

| Coating Line Type<br>Control Level | Facility size | | |
|---|---|---|---|
| | Large<br>$/MT($/ton) | Medium<br>$/MT($/ton) | Small<br>$/MT($/ton) |
| Without Recovery Credit | | | |
| Adhesive Coating Lines | | | |
| Alternative I | 235(214) | 436(396) | 861(786) |
| Alternative II | 244(222) | 415(377) | 812(736) |
| Alternative III | 241(219) | 420(382) | 782(709) |
| Silicone Release Coating Lines | | | |
| Alternative I | 451(410) | 1525(1398) | 4236(3851) |
| Alternative II | 434(395) | 1464(1329) | 4052(3715) |
| Alternative III | 425(387) | 1409(1270) | 3894(3583) |
| With Recovery Credits | | | |
| Adhesive Coating Lines | | | |
| Alternative I | [147]([133]) | 54(49) | 479(437) |
| Alternative II | [137]([125]) | 33(30) | 428(388) |
| Alternative III | [141]([129]) | 37(34) | 402(364) |
| Silicone Release Coating Lines | | | |
| Alternative I | 68(62) | 1146(1050) | 3836(3487) |
| Alternative II | 53(48) | 1073(974) | 3689(3382) |
| Alternative III | 44(40) | 1025(924) | 3503(3223) |

Note: [ ] indicates that there is a credit and not a cost for these cases.
MT = metric ton

## TABLE 8-27. ESTIMATED COST - EFFECTIVENESS OF INCINERATION CONTROL DEVICES ON MODEL FACILITIES (WITH AND WITHOUT HEAT RECOVERY CREDITS)

| Coating Line Type<br>Control Level | Facility size | | |
|---|---|---|---|
| | Large<br>$/MT($/ton) | Medium<br>$/MT($/ton) | Small<br>$/MT($/ton) |
| Without Recovery Credit | | | |
| Adhesive Coating Lines | | | |
| Alternative I | 164(149) | 415(377) | 921(834) |
| Alternative II | 162(148) | 402(365) | 856(777) |
| Alternative III | 157(143) | 401(364) | 820(748) |
| Silicone Release Coating Lines | | | |
| Alternative I | 409(371) | 1611(1457) | 4519(4108) |
| Alternative II | 387(351) | 1545(1405) | 4148(3803) |
| Alternative III | 376(342) | 1478(1350) | 3986(3667) |
| With Recovery Credits | | | |
| Adhesive Coating Lines | | | |
| Alternative I | [87]([79]) | 165(150) | 669(606) |
| Alternative II | [94]([85]) | 151(137) | 618(561) |
| Alternative III | [94]([86]) | 140(127) | 583(532) |
| Silicone Release Coating Lines | | | |
| Alternative I | 157(143) | 1354(1224) | 4268(3880) |
| Alternative II | 135(123) | 1288(1171) | 3875(3553) |
| Alternative III | 125(114) | 1234(1128) | 3724(3427) |

Note: [ ] indicates that there is a credit and not a cost for these cases.
MT = metric ton

only given for the recovered heat which is used in heating the ovens. In this report the credit is based on the cost of heating the adhesive and silicone ovens with natural gas. After the credits are applied, the cost-effectiveness values show that carbon adsorption systems are more cost-effective than incineration. In fact for the large model facilities, the carbon adsorption unit has an actual payout.

8.2.1.3 Emission Monitoring and Compliance Testing Costs. Emission monitoring of the exit gases should not be a major added cost for carbon adsorption or incineration. Most carbon adsorption units come equipped with hydrocarbon (LEL) monitors on the stack outlets. These monitors are used to measure hydrocarbon breakthrough during routine equipment cycling. They are also used to monitor the performance life of the carbon bed. The hydrocarbon monitor should be equipped with a chart/recorder to document the performance of the unit.

The incineration unit generally does not monitor outlet hydrocarbons, but does monitor incinerator temperatures. The incinerator temperature can be used as a reliable indicator of hydrocarbon destruction. Studies have shown that 90 percent reduction in hydrocarbon can occur at a temperature of 1250°F. A 95 percent hydrocarbon reduction can be expected at 1300°F.[82] A chart/recorder would also be needed here to document incinerator performance.

Compliance testing may also be required to prove the performance of the control system. Compliance testing will generally occur only one time during the lifetime of the unit. A detailed compliance test consisting of three inlet and three outlet tests will cost between ten and twenty thousand dollars.

Appendix D gives more information on emission measurement and continuous monitoring of controlled coating facilities.

8.2.1.4 Cost Associated with Increased Water Pollution or Solid Waste Disposal. The incineration control system will add no additional wastewater or solid wastes to the existing coating facility. Carbon adsorption has both a solid waste and a water waste. The solid waste is spent carbon. The spent carbon is usually sold back to processors for a much lower price than originally purchased. The processor will reactivate the carbon and sell it back to operators with carbon adsorption systems. Therefore, there is no disposed solid waste cost.

There are two potential water wastes from a carbon adsorption unit: (1) steam condensate separated from the organic phase and (2) cooling tower blowdown. The steam condensate can be recycled as boiler feedwater. Sometimes the condensate must be treated to control pH.[83] However, due to dissolved solids buildup there will have to be a blowdown of the recycled steam condensate. The boiler blowdown and cooling tower blowdown are expected to be small streams (less than 10 gpm) and, therefore, can be disposed of in a municipal sewer system if available. If not, the water will have to be treated so it will not decrease the quality of water into which it is being mixed. A carbon adsorption unit could be used to treat these wastes.

### 8.2.2 Modified/Reconstructed Facilities

The definitions of a modified or reconstructed plant are given in Chapter 5. Modifications and reconstructions will generally occur in existing facilities. The cost analysis presented in Section 8.2.1 can be applied to modification or reconstruction with the following qualifications:

- The capital cost of a modification or reconstruction will generally be less than a new facility. Therefore, the capital recovery factor will be less. This becomes more important in the smaller size facilities.
- Land requirements for control equipment may be critical for an existing facility. For a 10,000 acfm gas stream a carbon adsorption unit requires approximately 400 to 500 square feet for the adsorbers, not counting the boiler and cooling tower.[84] An incinerator requires less space than the carbon adsorber.
- Ducting costs may become more expensive if control equipment has to be located far from the coating lines.

Other cost items such as loss of production, installation labor and engineering costs should be examined with respect to how they would be different from new facility costs.

## 8.3 OTHER COST CONSIDERATIONS

The pressure sensitive tapes and labels industry comes under Federal regulation through several governmental agencies. There are six major areas of regulation[85]:

- environmental, involving air and water,
- health and safety of employees,
- transportation of raw materials,
- food additives (if the products are to be used in the
- food industry),
- skin contact (if the products will be used in direct
- contact with human skin), and
- consumer product safety.

This study is only concerned with control of airborne VOC emissions and their associated problems. Therefore, the remainder of the discussion concerns only items (1) and (2).

The responsibility of regulating environmental problems as they impact areas outside an affected facility is designated to local, state, and Federal environmental protection groups. The Federal Agency in this situation is the U. S. Environmental Protection Agency. The responsibility of regulating levels of emissions within the plant working area belongs to NIOSH (National Institute for Occupational Safety and Health) and OSHA (Occupational Safety and Health Administration). OSHA is a part of the United States Department of Labor and its responsibilities include final adoption of occupational exposure standards and enforcement of the standards through inspection of work places.[86] NIOSH is an agency of the United States Department of Health, Education, and Welfare, and part of its charter is to provide regulation support information to OSHA.

At the present the U. S. Environmental Protection Agency has no air emission regulations for the operation of pressure sensitive tapes and label coaters. The EPA has issued a guideline document [87] for control of coating operations, which the states are using to develop SIP regulations. The EPA also has authority to regulate chemical manufacturing through the Toxic Substances Control Act (15 U.S.C. 2601; October 12, 1976). As a rule this regulation applies only to operators who mix or

OSHA has worker area standards for nearly 500 chemicals. These standards are very similar to the Threshold Limit Values (TLV's) designated by the American Conference of Governmental Industrial Hygienists (ACGIH). The ACGIH define TLV as "concentrations of air-borne substances which represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect- ... TLV's refer to time-weighted concentrations for a seven or eight hour workday and a forty hour work week." This same definition may be used for OSHA exposure standards. The TLV's for typical solvents used in the pressure sensitive tapes and labels industry are shown in Table 8-28.

Control of worker area solvent concentrations is accomplished through containment, isolation, substitution, general ventilation, local exhaust ventilation, change of operating procedures, and administrative control.[88] When local exhaust ventilation is used, a canopy fume hood is commonly used. However, this is usually a poor choice for removing airborne contaminants from the work place and specifically from the breathing zones of employees.[91] Many other hooding techniques can be used and are discussed in the ACGIH Industrial Ventilation Manual. Around a coating area, a hooding system combined with a containment system can be very effective in limiting employee solvent exposure levels. The cost of a hood, ducting, and a fan is expected to be a small percent of the total capital cost of a new coating line (see Tables 8-23 or 8-24).

Another emission level constraint affecting the tape or label coater is the lower explosive limit (LEL) of solvents. Solvent explosions are not only a health and safety concern to the worker, they are a great concern to insurers of coating equipment. Insurance companies require strict monitoring of LEL levels in equipment areas where the LEL is high.

## TABLE 8-28. THRESHOLD LIMIT VALUES (TLV) AND LOWER EXPLOSIVE LIMITS (LEL) OF TYPICAL ADHESIVE AND RELEASE SOLVENTS

| Solvent | TLV[89] | | LEL[90] | |
|---|---|---|---|---|
| | $Mg/m^3$ | ppm | Vol.% | $lb/10^3ft^3$[a] |
| Toluene | 375 | 100 | 1.27 | 2.37 |
| Xylene | 435 | 100 | 1.0 | 2.32 |
| n-Hexane | (1800)[b] | (500)[b] | 1.3 | 2.75 |
| n-Heptane | (2000)[b] | (500)[b] | 1.0 | 2.40 |
| Cyclohexane | 1100 | 300 | 1.31 | 2.8 |
| Naphtha (VM &P) | NA | NA | 0.81 | 2.16 |
| Methyl Acetate | 610 | 200 | 4.1 | 7.45 |
| Ethyl Acetate | 1400 | 410 | 2.2 | 4.74 |
| n-Butyl Acetate | 710 | 150 | 1.7 | 4.83 |
| Acetone | 2400 | 1000 | 2.15 | 3.04 |
| Methyl Ethyl Ketone (MEK) | 590 | 200 | 1.81 | 3.20 |
| Methyl Isopropyl Ketone | 700 | 200 | 1.4 | 3.54 |
| Carbon Tetrachloride | 65[c] | 10[c] | NA | NA |
| Methanol | 260[c] | 200[c] | 6.0 | 4.70 |
| Ethanol | 1900 | 1000 | 3.3 | 3.72 |

[a] Calculated at 100°F.

[b] In the process of being changed.

[c] Can be potentially absorbed by the body through skin, eyes, or mucous membranes.

NA - not available

The highest LEL levels are found in the drying ovens. Most coatings systems are designed to maintain a 25 to 40 percent LEL level in the ovens. Table 8-28 lists LEL values for typical solvents used in the pressure sensitive tapes and labels industry. Meeting LEL levels is a design concern rather than an added cost due to Federal regulation.

## 8.4 ECONOMIC IMPACT ANALYSIS

The purpose of this section is to analyze the economic impacts of the regulatory alternatives for new production facilities in the pressure sensitive tapes and labels industry. Three types of production facilities are examined. One is an adhesive coating (PSA) line that coats a prerelease-coated web. A second is a silicone release coating (SR) line whose output is a silicone release-coated web. The third is a tandem line, that is, one that applies a release coating on one side and a pressure sensitive adhesive to the other side of a paper web. VOC emissions from these facilities can be controlled by using one of four control techniques: carbon adsorption (solvent recovery), incineration (solvent destruction), waterborne coatings, or 100 percent solids coatings.

These techniques can be used to meet one of three levels of control, which correspond to the regulatory alternatives described in Chapter 6. Under the "no regulation" alternative, production facilities have to meet the requirements of the State Implementation Plans (SIP's); for the purposes of this analysis this alternative would have no impact. The remaining two alternatives correspond to the moderate (Regulatory Alternative II) and stringent (Regulatory Alternative III) levels of control. (These alternatives are discussed in detail in Chapter 6.) Waterborne coatings and 100 percent solids coatings can meet the stringent control level not by employing add-on control equipment but by avoiding the use, and thus the emissions, of solvents in the coating process.

Three types of impacts are estimated. Price impacts are calculated assuming that all additional costs of the alternatives are passed forward to the consumer. Return on investment (ROI) impacts assume that these additional costs are absorbed by the producer, that is, that the product price does not change when costs increase. Finally, incremental capital requirements attributable to the regulatory alternatives are estimated.

In addition, impacts on the growth and structure of the industry are treated qualitatively based on the price, ROI, and capital requirement impacts. Section 8.4.1 summarizes these impacts. Section 8.4.2 describes the methodology used to estimate the impacts. Section 8.4.3 presents the cost data and parameter values used in the analysis. Sections 8.4.4, 8.4.5, and 8.4.6 contain the estimated impacts for large-, medium-, and small-scale facilities, respectively.

### 8.4.1 Summary

The regulatory alternatives would have an insignificant impact on the industry. When alternative technologies (waterborne coatings and 100 percent solids coatings) are available, they can meet the requirements of either the moderate or the stringent alternative. Since these systems are more profitable than conventional solvent-based systems, firms in the industry have an economic incentive to adopt them even in the absence of a regulation. Thus, the regulatory alternatives would not force firms constructing new facilities to deviate from the investment behavior they would exhibit in the absence of those alternatives.

In some cases, technological constraints preclude the use of these alternative technologies, that is, firms investing in new facilities must use a conventional solvent-based coating. The regulatory alternatives would have minor impacts in these cases. Under the moderate control level, price increases ranging from 0.0 to 0.4 percent would result. If the additional costs of control were absorbed by the producer, the baseline return on investment of 16 percent would decline from 0.0 to 0.6 percentage points. The impacts are slightly larger for the large-scale facilities than for the medium- and small-scale ones. Meeting the stringent control level by passing on all additional costs would raise prices by 0.0 to 0.9 percent. Full cost absorption would reduce the ROI by 0.0 to 1.0 percentage points. Again, the impacts on the small and medium facilities are smaller than those for the large-scale coating lines.

The regulatory alternatives would have little or no impact on the industry's growth rate and structure. The availability of alternative technologies and the small price and ROI impacts on the conventional solvent-based systems imply that the regulatory alternatives would not deter new investment and adversely affect growth. Although the large facilities would be affected more than the medium and small facilities, the difference is not great enough to put the large facilities at a competitive disadvantage. Thus, the regulatory alternatives would not cause any significant changes in the structure of the industry.

### 8.4.2 Methodology

The methodology used to estimate the impacts of the regulatory alternatives is described in this section. A discounted cash flow (DCF) approach is used to evaluate the profitability of investing in new production facilities and, more specifically, to determine which one of several alternative facilities is the most profitable for the firm. For each type and size of production facility, the firm can choose one of several possible configurations, which correspond to the control options (including the SIP options) for which cost data were provided in Section 8.2. Using the DCF approach, the most profitable configuration can be selected. The resulting choices show which facilities would be constructed by the industry in the absence of the regulatory alternatives and thus constitute a baseline from which the impacts of those alternatives can be measured.

The remainder of this section is organized as follows. A general description of the DCF approach is provided in Section 8.4.2.1. This background is needed in order to understand the particular application of the DCF approach which is used to estimate the economic impacts and which is presented in Section 8.4.2.2. Finally, how the impacts are calculated using this method is discussed in Section 8.4.2.3.

8.4.2.1 Discounted Cash Flow Approach. An investment project generates cash outflows and inflows. Cash outflows include the initial investment, operating expenses, and interest paid on borrowed funds. Cash inflows are the revenues from the sales of the output produced by the project, depreciation of the capital equipment, and recovery of the working capital at the end of the project's life. Cash outflows and inflows can occur at any time during the project's lifetime. For this analysis, it is assumed that all flows take place instantaneously at the end of each year. Furthermore, it is assumed that all investments are conventional investments, that is, they are represented by one cash outflow followed by one or more cash inflows.[92] This assumption insures the existence of a unique internal rate of return for each project.[93] For a project with a lifetime of N years, there are N + 1 points in time at which cash flows occur: at the end of year zero, the end of year one, and so on through the end of the Nth year.

The initial (and only) investment is assumed to be made at the end of year zero. This cash outflow comprises the sum of the fixed capital cost and the working capital. It is offset by an investment tax credit, which is calculated as a percentage of the fixed capital cost and represents a direct tax saving. The cash flow in year zero can be given by the following equation:

$$-Y_0 = -(FCC + WC) + (TCRED \times FCC) \qquad (8\text{-}1)$$

The variables for this and subsequent equations are defined in Table 8-29.

The project generates its first revenues (and incurs further costs) at the end of year one. The net cash flows in this and succeeding years can be represented by the following equation:

$$Y_t = (R_t - E_t - I_t)\ (1 - T) + D_t T \qquad t = 1, \ldots, N \qquad (8\text{-}2)$$

The first term of Equation 8-2 represents the after-tax inflows of the project generated by sales of the output after netting out all deductible expenses. Revenues are given by:

$$R_t = P \cdot Q \cdot U \qquad (8\text{-}3)$$

Deductible operating expenses, $E_t$, are the sum of the fixed and variable operating costs and can be represented by:

$$E_t = V \cdot U + F \qquad (8\text{-}4)$$

TABLE 8-29. DEFINITIONS

| Symbol | Explanation |
|---|---|
| $D_t$ | depreciation in year t |
| $DF_t$ | discount factor = $(1+r)^{-t}$ |
| DF | sum of the discount factors over the life of the project = $\sum_{t=0}^{N} (1+r)^{-t}$ |
| DSL | present value of the tax savings due to straight line depreciation = $\sum_{t=0}^{N} D_t T(1+r)^{-t}$ |
| $E_t$ | operating expenses in year t |
| F | annual fixed costs |
| FCC | fixed capital costs |
| $I_t$ | interest paid on borrowed funds in year t |
| N | project lifetime in years |
| NPV | net present value |
| P | price per unit of output |
| PDEBT | proportion of investment financed by borrowing |
| Q | annual plant capacity |
| $R_t$ | revenues in year t |
| $r_D$ | interest rate on borrowed funds |
| r | discount rate, or cost of capital |
| T | corporate tax rate |
| TCC | total capital cost |
| TCRED | investment tax credit |
| U | capacity utilization rate |
| V | annual variable operating costs |
| WC | working capital |
| X | minimum [$2000, .2 x FCC] |
| $Y_t$ | net cash flow in year t |

Variable costs include expenditures on raw materials, labor (operating, supervisory, and maintenance), utilities, and any credits for solvent or heat recovery. Fixed costs include expenditures for facility use, insurance, administrative overhead, etc. Interest paid on borrowed funds is a function of the proportion of the project financed by borrowing, the total capital cost of the project, and an interest rate and can be given by:

$$I_t = \text{PDEBT} \cdot \text{TCC} \cdot r_D \tag{8-5}$$

For income tax purposes, $E_t$ and $I_t$ are deductible from gross revenues, $R_t$. Hence, the after-tax cash inflow to the firm can be determined by netting out these expenses and multiplying the result by $(1 - T)$.

Federal income tax laws also allow a deduction for depreciation of the capital equipment (not including working capital). Although depreciation is not an actual cash flow, it does reduce income tax payments (which are cash outflows) since taxes are based on net income after deducting the depreciation allowance.[94] The expression in Equation 8-2, $D_tT$, represents the annual tax savings to the firm resulting from depreciation; it is treated as a cash inflow. In the analysis in this section, the straight line method of depreciation is used. The salvage value of the facility is assumed to be zero, so the annual depreciation expense is simply given by $(FCC - X)/N$, where $N$ is the lifetime of the project and $X$ is $2000 or 20 percent of the fixed capital costs, whichever is smaller.

The net cash flows represented by Equation 8-2 occur at the end of the first through the Nth years. Additional cash inflows occur at the end of the first and Nth year. The additional cash inflow at the end of the first year is the tax savings attributable to the additional first year depreciation deduction of 20 percent of the fixed capital cost or $2000, whichever is smaller. By law, the basis for calculating normal depreciation allowances must be reduced by the amount of the additional first year depreciation.[95] The additional cash inflow at the end of the Nth year occurs when the working capital, initially treated as a cash outflow, is recovered.

Because these cash flows occur over a future period of time, they must be discounted by an appropriate interest rate to reflect the fact that a sum of money received at some future date is worth less than if that sum were received at the present time. This discount factor, $DF_t$, can be given by:

$$DF_t = (1 + r)^{-t} \qquad t = 0, 1, \ldots, N \qquad (8\text{-}6)$$

The sum of the discounted cash flows from a project is called the net present value of that project. That is,

$$NPV = \overset{N}{\underset{t=0}{S}} Y_t \cdot DF_t \quad \text{or} \qquad (8\text{-}7)$$

$$NPV = \overset{N}{\underset{t=0}{S}} Y_t \, (1 + r)^{-t}.$$

The decision criterion is to invest in the project if it has a positive NPV at a discount rate equal to the weighted average cost of capital.

8.4.2.2 Project Ranking Criterion. The specific application of DCF used in the economic analysis is discussed in this section. What is needed is a criterion for ranking alternative investment projects in terms of profitability. It is assumed that, in the absence of the regulatory alternatives, any firm building a new production facility would invest in the most profitable configuration of that facility. This choice can be compared with the one that would have to be built to comply with the regulatory alternative; this forms the basis for calculating price and rate of return impacts.

Equation 8-7 can be rearranged and used as the ranking criterion. The procedure begins by substituting the expressions for R, E, and I (given by Equations 8-3, 8-4, and 8-5, respectively) in Equation 8-2. Next, the expressions for $Y_0$ in Equation 8-1 and $Y_t$ in Equation 8-2 are substituted for $Y_t$ in Equation 8-7. NPV in Equation 8-7 is then set equal to zero and the unit price, P, is solved for by rearranging the terms in $Y_t$ so that the price is on the left hand side of the equal sign and all other terms are on the right hand side:

$$P = \frac{Z}{DF\cdot(1-T)\cdot Q\cdot U} + \frac{V\cdot U + F + I}{Q\cdot U} \qquad (8\text{-}8)$$

where $Z = Y_0 - DSL - WC(1+r)^{-N} - X(1+r)^{-1}\cdot T$ and all other variables are defined in Table 8-29. The resulting expression for P has two terms. The first, or "capital cost," term is that part of the unit price accounted for by the initial capital outlay (adjusted for the tax savings attributable to depreciation, recovery of working capital, etc.) and including the return on the invested capital. The second, or "operating cost," term is a function of the fixed and variable operating costs. Hence, for any configuration, the price given by Equation 8-8 can be interpreted as the one that just covers the unit operating costs and yields a rate of return, r, over the project's lifetime on the unrecovered balances of the initial investment.

For each type and size of facility, Equation 8-8 is used to calculate the unit cost of the product from each configuration. The results are then ranked in order of cost, from lowest to highest. The most profitable configuration is the one that can produce a square meter of tape or label stock for the lowest cost. This ranking method yields the optimal solution to a simple form of the "constrained project selection problem."*

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*The selection of investment projects by a firm is unconstrained if the projects are independent and indivisible and if there is sufficient capital to invest in all projects with positive net present values. (A set of projects is economically independent if the acceptance of one project does not affect the acceptance or rejection of other projects in the set.) If one of these conditions is violated, the project selection process is said to be constrained. The configurations confronting the typical firm represent a set of mutually exclusive projects, that is, each line produces an identical product, namely, tape or label stock. Thus, the selection of one project automatically excludes the remaining projects. Since mutual exclusivity is a form of economic dependence among the projects in the set, the selection of investment projects by the firm is constrained.

Several assumptions are implicit in this ranking procedure. First, it is assumed that the objective of the firm is to maximize the future wealth of the firm's shareholders, which is the same as maximizing the firm's present value in a perfect capital market.[98] Second, the existence of a perfect capital market is assumed. This implies that the activities of the individual buyer or seller of securities has no effect on prices and that the individual firm can raise or invest as much cash as it desires at the market rate of interest. It also implies that market transactions are costless. A further implication of the perfect capital market assumption is that the rate of return to the firm's last investment (the marginal investment rate) is equal to the firm's marginal cost of capital. Third, it is assumed that investment outcomes are known with complete certainty. Fourth, an investment project is indivisible, that is, it must be undertaken in its entirety or not at all.

8.4.2.3 Determining the Impacts of the Regulatory Alternatives. This section describes how the impacts of the regulatory alternatives are estimated using the price ranking method discussed in Section 8.4.2.2. The estimated impacts are presented in Sections 8.4.4, 8.4.5, and 8.4.6. Three categories of impacts are estimated: price, return on investment, and incremental capital requirements.

Price impacts are calculated directly from Equation 8-8. The profit-maximizing line configuration is compared with the control requirement of the regulatory alternative (moderate or stringent). If it meets the requirement, there is no impact. If it does not, the unit cost of this configuration is used as the base price for calculating the price impacts. The unit cost associated with the highest ranked configuration that also meets the control requirement is compared with the base price to determine the magnitude of the price impact.

Whereas price impacts are calculated by assuming that all of the incremental costs associated with a given control option are passed forward to the consumer, return on investment (ROI) impacts are estimated by assuming that the producer absorbs all of the incremental costs, thus lowering the ROI. In this case, the price facing the consumer would not change. For any control option, there exists a discount rate that would enable the producer to maintain the price at its baseline level. The baseline price is the price associated with the most profitable line configuration and is determined from the procedure described in Section 8.4.2.2.

The baseline price was calculated from Equation 8-8 using a specific value of the discount rate, $\bar{r}$. The calculation of the rate of return impact would begin by setting $P = \bar{P}$ in Equation 8-8, where $\bar{P}$ is the baseline (lowest) price and then iteratively solving for the value of $r$ that equates the right hand side of Equation 8-8 with $\bar{P}$. This value, say $r^*$, will always be less than $\bar{r}$, the baseline rate of return. The difference between $r^*$ for each control option and $\bar{r}$ constitutes the rate of return impact.

The incremental capital requirements are calculated from the cost data presented in Section 8.2. The additional capital required to meet the standards is used as a partial measure of the financial difficulty firms might face in attempting to conform to the standard. Incremental capital requirements also constitute a barrier for firms entering the industry. The magnitude of the additional capital relative to the baseline capital requirements is a measure of the size of this barrier.

### 8.4.3 Cost Data and Parameter Values

This section presents the cost data and the values of key parameters used in the analysis. It also describes the format of the analysis whose results are given in Sections 8.4.4, 8.4.5, and 8.4.6.

The four basic control techniques can be applied to each type of facility. Hence, for each type and size of facility the firm is confronted with a set of eight line configurations: three using carbon adsorbers, three employing incinerators, a waterborne coating line, and a hot melt or 100 percent solids coating line. Tables 8-30, 8-31, and 8-32 present the costs used in the economic analysis for the large, medium, and small coating facilities, respectively. Each table shows the costs for the pressure sensitive adhesive (PSA) coating operation, the silicone release (SR) coating operation, and the tandem coating operation for each of the eight possible control options. These costs

TABLE 8-30. CAPITAL AND OPERATING COSTS OF LARGE COATING LINES (000$)

|  | PSA lines |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
| Type of control | Carbon adsorption |  |  | Incineration |  |  | Water | Hot melt |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent |  |  |
| Capital costs |  |  |  |  |  |  |  |  |
| Installed capital | 3,000 | 3,240 | 3,292 | 2,556 | 2,574 | 2,628 | 2,040 | 1,200 |
| Working capital | 1,369 | 1,369 | 1,369 | 1,279 | 1,279 | 1,279 | 1,241 | 1,208 |
| Total | 4,369 | 4,609 | 4,661 | 3,835 | 3,853 | 3,907 | 3,281 | 2,408 |
| Annual operating costs |  |  |  |  |  |  |  |  |
| Fixed | 556 | 570 | 572 | 531 | 532 | 535 | 519 | 404 |
| Variable$^a$ | 8,907<br>(9,500) | 8,839<br>(9,494) | 8,805<br>(9,489) | 9,329 | 9,361 | 9,377 | 8,763 | 8,382 |

|  | SR lines |  |  |  |  |  |  |  |
|---|---|---|---|---|---|---|---|---|
| Type of control | Carbon adsorption |  |  | Incineration |  |  | Water | 100% solids |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent |  |  |
| Capital costs |  |  |  |  |  |  |  |  |
| Installed capital | 1,438 | 1,452 | 1,472 | 1,445 | 1,452 | 1,471 | 1,200 | 936 |
| Working capital | 485 | 485 | 485 | 471 | 471 | 471 | 450 | 450 |
| Total | 1,923 | 1,937 | 1,957 | 1,916 | 1,923 | 1,942 | 1,650 | 1,386 |
| Annual operating costs |  |  |  |  |  |  |  |  |
| Fixed | 467 | 468 | 468 | 468 | 468 | 469 | 454 | 352 |
| Variable$^a$ | 3,585<br>(3,673) | 3,576<br>(3,672) | 3,572<br>(3,673) | 3,642 | 3,645 | 3,650 | 3,440 | 3,367 |

(continued)

TABLE 8-30 (continued)

| Type of control | Tandem lines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Carbon adsorption | | | Incineration | | | Water | Hot melt/ 100% solids |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent | | |
| Capital costs | | | | | | | | |
| Installed capital | 4,464 | 4,560 | 4,656 | 3,780 | 3,792 | 3,875 | 3,240 | 2,136 |
| Working capital | 1,439 | 1,439 | 1,439 | 1,335 | 1,335 | 1,335 | 1,001 | 969 |
| Total | 5,903 | 5,999 | 6,095 | 5,115 | 5,127 | 5,210 | 4,241 | 3,105 |
| Annual operating costs | | | | | | | | |
| Fixed | 738 | 744 | 749 | 699 | 700 | 705 | 939 | 876 |
| Variable[a] | 9,493<br>(10,174) | 9,409<br>(10,160) | 9,371<br>(10,157) | 9,960 | 9,994 | 10,015 | 7,603 | 7,269 |

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[a] For lines with carbon adsorbers the unparenthesized entry was calculated using the full credit for recovered solvent reported in Section 8.2. The numbers in parentheses were calculated using half the credit for recovered solvent.

TABLE 8-31. CAPITAL AND OPERATING COSTS OF MEDIUM COATING LINES (000$)

| Type of control | PSA lines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Carbon adsorption | | | Incineration | | | Water | Hot melt |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent | | |
| Capital costs | | | | | | | | |
| Installed capital | 1,723 | 1,728 | 1,741 | 1,738 | 1,742 | 1,752 | 1,500 | 883 |
| Working capital | 191 | 191 | 191 | 178 | 178 | 178 | 173 | 168 |
| Total | 1,914 | 1,919 | 1,932 | 1,916 | 1,920 | 1,930 | 1,673 | 1,051 |
| Annual operating costs | | | | | | | | |
| Fixed | 395 | 395 | 396 | 395 | 396 | 396 | 385 | 290 |
| Variable[a] | 1,561 | 1,553 | 1,553 | 1,620 | 1,622 | 1,624 | 1,479 | 1,349 |
| | (1,642) | (1,641) | (1,641) | | | | | |

| Type of control | SR lines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Carbon adsorption | | | Incineration | | | Water | 100% solids |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent | | |
| Capital costs | | | | | | | | |
| Installed capital | 977 | 978 | 985 | 1,002 | 1,004 | 1,013 | 888 | 691 |
| Working capital | 68 | 68 | 68 | 66 | 66 | 66 | 63 | 63 |
| Total | 1,045 | 1,046 | 1,053 | 1,068 | 1,070 | 1,079 | 951 | 754 |
| Annual operating costs | | | | | | | | |
| Fixed | 352 | 352 | 353 | 354 | 354 | 355 | 350 | 339 |
| Variable[a] | 789 | 787 | 787 | 798 | 799 | 800 | 759 | 749 |
| | (801) | (800) | (801) | | | | | |

(continued)

TABLE 8-31. (continued)

| Type of control | Tandem lines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Carbon adsorption | | | Incineration | | | Water | Hot melt/ |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent | | 100% solids |
| Capital costs | | | | | | | | |
| Installed capital | 2,635 | 2,648 | 2,664 | 2,640 | 2,645 | 2,663 | 2,388 | 1,574 |
| Working capital | 200 | 200 | 200 | 186 | 186 | 186 | 140 | 135 |
| Total | 2,835 | 2,848 | 2,864 | 2,826 | 2,831 | 2,849 | 2,528 | 1,709 |
| Annual operating costs | | | | | | | | |
| Fixed | 536 | 536 | 536 | 536 | 536 | 537 | 552 | 505 |
| Variable[a] | 1,783<br>(1,877) | 1,772<br>(1,873) | 1,773<br>(1,875) | 1,849 | 1,852 | 1,855 | 1,418 | 1,338 |

[a] For lines with carbon adsorbers the unparenthesized entry was calculated using the full credit for recovered solvent reported in Section 8.2. The numbers in parentheses were calculated using half the credit for recovered solvent.

TABLE 8-32. CAPITAL AND OPERATING COSTS OF SMALL COATING LINES (000$)

| | PSA lines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type of control | Carbon adsorption | | | Incineration | | | Water | Hot melt |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent | | |
| Capital costs | | | | | | | | |
| Installed capital | 1,296 | 1,297 | 1,305 | 1,327 | 1,332 | 1,342 | 1,176 | 693 |
| Working capital | 60 | 60 | 60 | 56 | 56 | 56 | 54 | 53 |
| Total | 1,356 | 1,357 | 1,365 | 1,383 | 1,388 | 1,398 | 1,230 | 746 |
| Annual operating costs | | | | | | | | |
| Fixed | 311 | 310 | 311 | 312 | 312 | 313 | 306 | 278 |
| Variable[a] | 653 | 651 | 650 | 675 | 675 | 677 | 603 | 566 |
| | (679) | (679) | (679) | | | | | |

| | SR lines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Type of control | Carbon adsorption | | | Incineration | | | Water | 100% solids |
| Level of control | SIP | Moderate | Stringent | SIP | Moderate | Stringent | | |
| Capital costs | | | | | | | | |
| Installed capital | 761 | 762 | 767 | 768 | 770 | 775 | 696 | 540 |
| Working capital | 21 | 21 | 21 | 21 | 21 | 21 | 20 | 20 |
| Total | 782 | 783 | 788 | 789 | 791 | 796 | 716 | 560 |
| Annual operating costs | | | | | | | | |
| Fixed | 280 | 280 | 280 | 281 | 281 | 281 | 279 | 269 |
| Variable[a] | 399 | 399 | 399 | 403 | 403 | 403 | 384 | 376 |
| | (403) | (403) | (403) | | | | | |

(continued)

TABLE 8-32. (continued)

| Type of control<br>Level of control | Tandem lines | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Carbon adsorption | | | Incineration | | | Water | Hot melt/ 100% solids |
| | SIP | Moderate | Stringent | SIP | Moderate | Stringent | | |
| Capital costs | | | | | | | | |
| Installed capital | 2,000 | 2,005 | 2,015 | 2,032 | 2,038 | 2,050 | 1,872 | 1,233 |
| Working capital | 63 | 63 | 63 | 58 | 58 | 58 | 44 | 42 |
| Total | 2,063 | 2,068 | 2,078 | 2,090 | 2,096 | 2,108 | 1,916 | 1,275 |
| Annual operating costs | | | | | | | | |
| Fixed | 439 | 440 | 440 | 441 | 441 | 442 | 462 | 426 |
| Variable[a] | 809 | 807 | 806 | 835 | 835 | 836 | 667 | 622 |
| | (839) | (839) | (840) | | | | | |

[a] For lines with carbon adsorbers the unparenthesized entry was calculated using the full credit for recovered solvent reported in Section 8.2. The numbers in parentheses were calculated using half the credit for recovered solvent.

include expenditures for pollution control equipment. The capital investment required for each line is divided into the installed capital cost and the working capital, which was estimated at 15 percent of the raw materials cost. Annual operating costs, classified as fixed and variable, are also shown. The operating costs do not include the annualized capital charge, since the DCF approach explicitly accounts for depreciation of equipment and recovery of the initial capital investment. Two variable operating costs are shown for coating lines using carbon adsorption as the control technique. The first allows the full credit for the recovered solvent as reported in Section 8.2. The second cost in parentheses is calculated by allowing only one-half the credit. Two credits are used because the relative profitability of lines fitted with carbon adsorbers is directly related to the value of the recovered solvent.

The costs of each configuration were inserted into Equation 8-8 to determine the unit cost of producing tape or label stock. It was assumed that capital equipment was depreciated over 10 years using the straight line method; that the corporate tax rate was 46 percent; that the investment tax credit was 10 percent; and that the discount rate was 16 percent (this was the most conservative estimate of the cost of equity capital presented in Section 8.1.5.1). It was also assumed that the investment was financed out of equity or retained earnings (the cost of capital is the same for both sources[99]). Since there is no borrowing, the proportion of the investment financed by issuing debt, PDEBT, is zero; consequently, the interest paid on borrowed funds in year t of the investment project, $I_t$, is also zero. This assumption, while unrealistic, does produce "worst case" results, since the after-tax cost of debt capital, which is around 5 to 6 percent, is less than the cost of equity capital for the industry. In general, any given investment project would be more attractive if a portion of the investment were financed by issuing debt. Two utilization rates were used in the analysis, 100 percent and 75 percent. Data on actual utilization rates were not available, so these two rates were arbitrarily chosen to provide an idea of the sensitivity of the results to changes in capacity utilization.

Sections 8.4.4, 8.4.5, and 8.4.6 present the estimated impacts for large, medium, and small coating facilities, respectively. Impacts are estimated for two cases. In one case, it is assumed that the firm can select a line configuration from the complete set of eight; this is the unconstrained case, labeled A in the following analysis. The second, or constrained, case eliminates the 100 percent solids and waterborne coatings configurations from the project selection set, which is labeled B, under the assumption that the resulting product is not perfectly substitutable for tape and label stock produced by conventional solvent-based coating lines.

### 8.4.4 Economic Impacts on Large Facilities

The economic impacts of the regulatory alternatives on large-scale coating facilities are presented in this section. The impacts in Section 8.4.4.1 are based on the costs reported in Table 8-30 that include the full credit for recovered solvent for the carbon adsorption lines. Those in Section 8.4.4.2 were also estimated from the costs in Table 8-30, except that only one-half the credit for recovered solvent was used in calculating the operating costs for the carbon adsorption lines. Section 8.4.4.3 summarizes the results.

8.4.4.1 Impacts Based on Full Credit for Recovered Solvent. Table 8-33 presents the unit costs and the associated rankings of the large-scale PSA, SR, and tandem facilities. Two costs are given for each facility, one based on a capacity utilization rate of 100 percent (Scenario 1), the other on a rate of 75 percent (Scenario 2). Each unit cost is ranked twice. The first set of rankings, labeled A, assumes that firms can invest in the alternative coating technologies (waterborne coatings and 100 percent solids coatings) as well as in the conventional solvent-based coating technologies. The second set, labeled B, assumes that firms are restricted to conventional solvent-based coating lines whose emissions are controlled by incinerators or carbon adsorbers.

The price impacts shown in Table 8-34 are based on these rankings. The impacts for each affected facility were estimated for two regulatory alternatives corresponding to moderate and stringent levels of control.

## TABLE 8-33. UNIT COSTS AND RANKINGS FOR LARGE FACILITIES[a]

| Line configuration | Scenario 1[b] | | | | | | | | | Scenario 2[c] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSA line | | | SR line | | | Tandem line | | | PSA line | | | SR line | | | Tandem line | | |
| | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | |
| | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] |
| Adsorption: SIP | 0.273 | 3 | 1 | 0.117 | 3 | 1 | 0.303 | 5 | 3 | 0.288 | 3 | 1 | 0.126 | 4 | 2 | 0.323 | 4 | 2 |
| Adsorption: moderate | 0.273 | 3 | 1 | 0.117 | 3 | 1 | 0.302 | 4 | 2 | 0.289 | 4 | 2 | 0.125 | 3 | 1 | 0.322 | 3 | 1 |
| Adsorption: stringent | 0.273 | 3 | 1 | 0.117 | 3 | 1 | 0.301 | 3 | 1 | 0.288 | 3 | 1 | 0.126 | 4 | 2 | 0.322 | 3 | 1 |
| Incineration: SIP | 0.280 | 4 | 2 | 0.119 | 4 | 2 | 0.309 | 6 | 4 | 0.293 | 5 | 3 | 0.127 | 5 | 3 | 0.326 | 5 | 3 |
| Incineration: moderate | 0.281 | 5 | 3 | 0.119 | 4 | 2 | 0.310 | 7 | 5 | 0.294 | 6 | 4 | 0.127 | 5 | 3 | 0.327 | 6 | 4 |
| Incineration: stringent | 0.281 | 5 | 3 | 0.119 | 4 | 2 | 0.311 | 8 | 6 | 0.295 | 7 | 5 | 0.127 | 5 | 3 | 0.329 | 7 | 5 |
| Waterborne | 0.261 | 2 | N/A | 0.111 | 2 | N/A | 0.248 | 2 | N/A | 0.273 | 2 | N/A | 0.119 | 2 | N/A | 0.266 | 2 | N/A |
| Hot melt (100% solids) | 0.242 | 1 | N/A | 0.105 | 1 | N/A | 0.230 | 1 | N/A | 0.252 | 1 | N/A | 0.111 | 1 | N/A | 0.245 | 1 | N/A |

[a] All calculations were made assuming straight line depreciation of capital equipment over 10 years, a corporate tax rate of 46 percent, an investment tax credit of 10 percent, a discount rate of 16 percent, and that the investment was financed out of retained earnings (no borrowing). Capacity of each line = 39 × $10^6$ m². Cost data taken from Table 8-30 using full credit for recovered solvent.

[b] Capacity utilization = 100 percent (based on 6,000 operating hours per year).

[c] Capacity utilization = 75 percent.

[d] Project set A is the unrestricted set, that is, the firm can invest in traditional or alternative coating technologies. Unit costs are ranked from lowest (rank = 1) to highest.

[e] Project set B is the restricted set, that is, the firm cannot invest in the alternative coating technologies (waterborne and hot melt or 100% solids) for technical reasons.

N/A = not applicable.

TABLE 8-34. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON LARGE FACILITIES (%)[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.00 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.80 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.00 |

[a] Calculated from the costs and rankings in Table 8-33. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the unit cost associated with the configuration is used as the base from which the price impact is calculated.

A requirement that all affected facilities meet the moderate level of control would have no impact. Firms confronted with project set A would invest in either the hot melt (or 100 percent solids) process (rank = 1) or a waterborne coating line (rank = 2), both of which meet the requirements of the moderate regulatory alternative. Firms confronted with project set B would invest in a carbon adsorption line that met either the moderate or stringent level of control, depending on the facility and the scenario (see Table 8-33). Since these choices are assumed to be made in the absence of a regulation, imposition of the moderate regulatory alternative would have no impact. Under the stringent regulatory alternative, there would be no price impact for the PSA and tandem facilities. The only impact of this alternative shown in Table 8-34 is a price increase of 0.8 percent for the SR facility when capacity is not fully utilized.

Table 8-35 shows the return on investment (ROI) impacts of the regulatory alternatives. (These are calculated by assuming that the firm absorbs any cost increase rather than passing it on to the consumer.) The moderate control level would have no impact on the baseline ROI of 16 percent for the reasons given above for the price impacts. Under the stringent alternative the SR facility would have to accept a 0.6 percentage point decline (from 16.0 to 15.4 percent) in its ROI to maintain the baseline price in Scenario 2; if capacity were fully utilized, there would be no impact. The PSA and tandem facilities would not be affected under either scenario.

The only incremental capital outlay called for by the regulatory alternatives occurs under Scenario 2 of the stringent control level. In this case, a firm investing in a SR facility would have to expend an additional $20 thousand, a one percent increase in the baseline capital investment, to bring the facility into compliance.

8.4.4.2 Impacts Based on Half Credit for Recovered Solvent. Table 8-36 presents the unit costs and rankings for the large-scale PSA, SR, and tandem facilities that were calculated using the other set of operating costs for all carbon adsorption facilities. The unit costs of the incineration, waterborne, and hot melt (100 percent solids)

TABLE 8-35. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON LARGE FACILITIES[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| Baseline ROI | 16.00 | 16.00 | 16.00 | 16.00 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.00 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | -0.61 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.00 |

[a] Table entries represent percentage point decreases in the baseline ROI. Impacts are calculated from the costs and rankings in Table 8-33. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the table entry is the amount by which the baseline ROI of 16 percent must decline to allow the firm to meet the price associated with the line configuration of rank one.

# TABLE 8-36. UNIT COSTS AND RANKINGS FOR LARGE FACILITIES[a]

| | Scenario 1[b] | | | | | | | | | Scenario 2[c] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSA line | | | SR line | | | Tandem line | | | PSA line | | | SR line | | | Tandem line | | |
| | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | |
| Line configuration | ($/m$^2$) | A[d] | B[e] | ($/m$^2$) | A[d] | B[e] | ($/m$^2$) | A[d] | B[e] | ($/m$^2$) | A[d] | B[e] | ($/m$^2$) | A[d] | B[e] | ($/m$^2$) | A[d] | B[e] |
| Adsorption: SIP | 0.288 | 5 | 3 | 0.119 | 3 | 1 | 0.320 | 6 | 4 | 0.303 | 6 | 4 | 0.128 | 4 | 2 | 0.340 | 6 | 4 |
| Adsorption: moderate | 0.290 | 6 | 4 | 0.119 | 3 | 1 | 0.321 | 7 | 5 | 0.306 | 7 | 5 | 0.128 | 4 | 2 | 0.341 | 7 | 5 |
| Adsorption: stringent | 0.290 | 6 | 4 | 0.120 | 4 | 2 | 0.322 | 8 | 6 | 0.306 | 7 | 5 | 0.128 | 4 | 2 | 0.342 | 8 | 6 |
| Incineration: SIP | 0.280 | 3 | 1 | 0.119 | 3 | 1 | 0.309 | 3 | 1 | 0.293 | 3 | 1 | 0.127 | 3 | 1 | 0.326 | 3 | 1 |
| Incineration: moderate | 0.281 | 4 | 2 | 0.119 | 3 | 1 | 0.310 | 4 | 2 | 0.294 | 4 | 2 | 0.127 | 3 | 1 | 0.327 | 4 | 2 |
| Incineration: stringent | 0.281 | 4 | 2 | 0.119 | 3 | 1 | 0.311 | 5 | 3 | 0.295 | 5 | 3 | 0.127 | 3 | 1 | 0.329 | 5 | 3 |
| Waterborne | 0.261 | 2 | N/A | 0.111 | 2 | N/A | 0.248 | 2 | N/A | 0.273 | 2 | N/A | 0.119 | 2 | N/A | 0.266 | 2 | N/A |
| Hot melt (100% solids) | 0.242 | 1 | N/A | 0.105 | 1 | N/A | 0.230 | 1 | N/A | 0.252 | 1 | N/A | 0.111 | 1 | N/A | 0.245 | 1 | N/A |

[a] All calculations were made assuming straight line depreciation of capital equipment over 10 years, a corporate tax rate of 46 percent, an investment tax credit of 10 percent, a discount rate of 16 percent, and that the investment was financed out of retained earnings (no borrowing). Capacity of each line = 39 × 10$^6$ m$^2$. Cost data taken from Table 8-30 using half credit for recovered solvent.

[b] Capacity utilization = 100 percent (based on 6,000 operating hours per year).

[c] Capacity utilization = 75 percent.

[d] Project set A is the unrestricted set, that is, the firm can invest in traditional or alternative coating technologies. Unit costs are ranked from lowest (rank = 1) to highest.

[e] Project set B is the restricted set, that is, the firm cannot invest in the alternative coating technologies (waterborne and hot melt or 100% solids) for technical reasons.

N/A = not applicable.

facilities are the same as those reported in Table 8-33, but the rankings are different. In general, the incineration facilities become more profitable than the carbon adsorption facilities when the value of the recovered solvent is halved.

Price impacts of the regulatory alternatives are given in Table 8-37. Under the moderate alternative, there would be no impact on any facility for firms that could invest in the alternative coating technologies (project set A). Firms choosing from project set B would have to raise prices by approximately 0.3 percent on the output of the PSA and tandem facilities; there is no price impact on the SR coating facility. The impacts are slightly larger under the stringent regulatory alternative if the waterborne coating and hot melt lines cannot be used. Price impacts for the PSA facilities range from 0.4 to 0.7 percent and from 0.7 to 0.9 percent for the tandem lines. Again, the SR coating lines are not affected. There is no impact on any facility if the alternative coating technologies can be used.

Table 8-38 shows the ROI impacts of the regulatory alternatives. The moderate control level would decrease the baseline ROI of the PSA and tandem lines by 0.3 to 0.6 percentage points; the SR lines would not be affected. The stringent control level would result in a one percentage point decrease for the PSA and tandem facilities. These impacts occur only for project set B, that is, when firms cannot use the waterborne coating and hot melt technologies.

The incremental capital requirements associated with these impacts are not severe. PSA facilities would require additional outlays of $18 thousand and $72 thousand to comply with the moderate and stringent control levels, respectively. These amounts represent 0.5 and 1.9 percent of the baseline investment. Tandem facilities would need an additional $12 thousand and $95 thousand to bring them into compliance with the moderate and stringent control levels, respectively. This is 0.2 and 1.9 percent of the baseline capital investment.

8.4.4.3 Summary of Economic Impacts. Firms that can use the alternative coating technologies (project set A) would suffer no impact under either of the regulatory alternatives. The profitability of the

TABLE 8-37. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON LARGE FACILITIES (%)[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.36 | 0.34 | 0.36 | 0.68 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.00 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.32 | 0.31 | 0.65 | 0.92 |

[a] Calculated from the costs and rankings in Table 8-36. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the unit cost associated with the configuration is used as the base from which the price impact is calculated.

TABLE 8-38. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON LARGE FACILITIES[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| Baseline ROI | 16.00 | 16.00 | 16.00 | 16.00 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | -0.36 | -0.53 | -0.93 | -1.02 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.00 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | -0.31 | -0.55 | -0.96 | -1.11 |

[a] Table entries represent percentage point decreases in the baseline ROI. Impacts are calculated from the costs and rankings in Table 8-36. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the table entry is the amount by which the baseline ROI of 16 percent must decline to allow the firm to meet the price associated with the line configuration of rank one.

waterborne coating and hot melt (100 percent solids) lines insures that firms would invest in them over the conventional solvent-based coating lines in the absence of a regulation. Since these facilities meet the requirements of the moderate and stringent control levels, there would be no impact if either regulatory alternative were imposed.

If firms cannot use the alternative technologies (project set B), some small impacts would result. Under the moderate regulatory alternative, the price impacts for the PSA and tandem facilities would range from 0.0 to 0.4 percent; there is no impact for the SR facilities. The baseline ROI for these facilities would decline by 0.0 to 0.6 percentage points. Under the stringent control level, the price increases range from 0.0 to 0.9 percent; the corresponding ROI decreases range from 0.0 to 1.0 percentage points. The incremental capital requirements of the regulatory alternatives range from 0.0 to 1.9 percent of the baseline investment.

The impact on the growth rate of output from large-scale facilities attributable to the regulatory alternatives would be minor. The existence of alternative technologies that not only meet the control level requirements but also are more profitable than conventional coating technologies is one factor that leads to this conclusion. Another factor is the small size of the price and ROI impacts when they do occur. Finally, the magnitude of the additional capital outlays should not preclude an investment in any of the affected facilities.

### 8.4.5 Economic Impacts on Medium Facilities

The economic impacts of the regulatory alternatives on medium-scale coating facilities are presented in this section. Following the format used for the large facilities in Section 8.4.4, the impacts in Section 8.4.5.1 are based on the cost data reported in Table 8-31 that include the full credit for recovered solvent for the carbon adsorption lines. Those in Section 8.4.5.2 were estimated from the same cost data, except that the value of the recovered solvent from the carbon adsorption lines was halved. Section 8.4.5.3 summarizes the results.

## TABLE 8-39. UNIT COSTS AND RANKINGS FOR MEDIUM FACILITIES[a]

| Line configuration | Scenario 1[b] | | | | | | | | | Scenario 2[c] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSA line | | | SR line | | | Tandem line | | | PSA line | | | SR line | | | Tandem line | | |
| | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] |
| Adsorption: SIP | 0.456 | 5 | 3 | 0.262 | 3 | 1 | 0.567 | 4 | 2 | 0.511 | 4 | 2 | 0.301 | 4 | 2 | 0.646 | 4 | 2 |
| Adsorption: moderate | 0.454 | 3 | 1 | 0.262 | 3 | 1 | 0.566 | 3 | 1 | 0.510 | 3 | 1 | 0.300 | 3 | 1 | 0.645 | 3 | 1 |
| Adsorption: stringent | 0.455 | 4 | 2 | 0.262 | 3 | 1 | 0.567 | 4 | 2 | 0.511 | 4 | 2 | 0.301 | 4 | 2 | 0.646 | 4 | 2 |
| Incineration: SIP | 0.467 | 6 | 4 | 0.265 | 4 | 2 | 0.579 | 5 | 3 | 0.522 | 5 | 3 | 0.304 | 5 | 3 | 0.658 | 5 | 3 |
| Incineration: moderate | 0.467 | 6 | 4 | 0.265 | 4 | 2 | 0.580 | 6 | 4 | 0.523 | 6 | 4 | 0.305 | 6 | 4 | 0.658 | 5 | 3 |
| Incineration: stringent | 0.468 | 7 | 5 | 0.266 | 5 | 3 | 0.581 | 7 | 5 | 0.524 | 7 | 5 | 0.305 | 6 | 4 | 0.660 | 6 | 4 |
| Waterborne | 0.427 | 2 | N/A | 0.251 | 2 | N/A | 0.487 | 2 | N/A | 0.478 | 2 | N/A | 0.288 | 2 | N/A | 0.562 | 2 | N/A |
| Hot melt (100% solids) | 0.355 | 1 | N/A | 0.238 | 1 | N/A | 0.424 | 1 | N/A | 0.390 | 1 | N/A | 0.271 | 1 | N/A | 0.483 | 1 | N/A |

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[a] All calculations were made assuming straight line depreciation of capital equipment over 10 years, a corporate tax rate of 46 percent, an investment tax credit of 10 percent, a discount rate of 16 percent, and that the investment was financed out of retained earnings (no borrowing). Capacity of each line = 5.4 × 10⁶ m². Cost data taken from Table 8-31 using full credit for recovered solvent.

[b] Capacity utilization = 100 percent (based on 6,000 operating hours per year).

[c] Capacity utilization = 75 percent.

[d] Project set A is the unrestricted set, that is, the firm can invest in traditional or alternative coating technologies. Unit costs are ranked from lowest (rank = 1) to highest.

[e] Project set B is the restricted set, that is, the firm cannot invest in the alternative coating technologies (waterborne and hot melt or 100% solids) for technical reasons.

N/A = not applicable.

8.4.5.1 Impacts Based on Full Credit for Recovered Solvent. Table 8-39 presents the unit costs and associated rankings for the PSA, SR, and tandem facilities under two scenarios. As with the large-scale facilities each line configuration is ranked twice to simulate the two project sets from which firms choose the most profitable investment. All price, ROI, and capital requirement impacts are based on these costs and rankings.

The price impacts of the moderate and stringent regulatory alternatives are given in Table 8-40. No increase in price from any affected facility would be required to meet the moderate control level even if firms could not use the alternative technologies. Firms that can invest in a line configuration from project set A would not have to raise prices to meet the stringent control level. If firms had to select from project set B, price impacts of 0.2 percent would result for the PSA and tandem facilities and would range from 0.0 to 0.3 percent for the SR coating lines.

The ROI impacts of the moderate and stringent control levels are shown in Table 8-41 as percentage point decreases in a baseline ROI of 16 percent. No impact on any facility would result under the moderate regulatory alternative. To meet the stringent control level without raising prices, firms would have to accept a drop in the ROI ranging from 0.1 to 0.2 percentage points for PSA lines, from 0.0 to 0.3 percentage points for SR lines, and of 0.1 percentage points for tandem facilities. If the firm could choose from project set A, there would be no ROI impacts.

No additional capital is required to comply with the moderate control level. The incremental capital requirements of the stringent regulatory alternative are $13 thousand for a PSA line, $7 thousand for a SR line, and $16 thousand for a tandem line. Each amount represents about 0.7 percent of the capital investment that would have been needed in the absence of the regulation. Additional capital would be required only if firms cannot use the alternative coating technologies.

8.4.5.2 Impacts Based on Half Credit for Recovered Solvent. Table 8-42 presents the unit costs and rankings for the PSA, SR, and

### TABLE 8-40. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON MEDIUM FACILITIES (%)[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.22 | 0.20 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | 0.33 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.18 | 0.16 |

[a] Calculated from the costs and rankings in Table 8-39. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the unit cost associated with the configuration is used as the base from which the price impact is calculated.

### TABLE 8-41. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON MEDIUM FACILITIES[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| Baseline ROI | 16.00 | 16.00 | 16.00 | 16.00 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | -0.22 | -0.13 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.00 | -0.25 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | -0.11 | -0.13 |

[a] Table entries represent percentage point decreases in the baseline ROI. Impacts are calculated from the costs and rankings in Table 8-39. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the table entry is the amount by which the baseline ROI of 16 percent must decline to allow the firm to meet the price associated with the line configuration of rank one.

## TABLE 8-42. UNIT COSTS AND RANKINGS FOR MEDIUM FACILITIES[a]

| Line configuration | Scenario 1[b] | | | | | | | | | Scenario 2[c] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSA line | | | SR line | | | Tandem line | | | PSA line | | | SR line | | | Tandem line | | |
| | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] |
| Adsorption: SIP | 0.471 | 5 | 3 | 0.264 | 3 | 1 | 0.584 | 6 | 4 | 0.526 | 6 | 4 | 0.303 | 3 | 1 | 0.663 | 5 | 3 |
| Adsorption: moderate | 0.471 | 5 | 3 | 0.264 | 3 | 1 | 0.584 | 6 | 4 | 0.526 | 6 | 4 | 0.303 | 3 | 1 | 0.664 | 6 | 4 |
| Adsorption: stringent | 0.471 | 5 | 3 | 0.265 | 4 | 2 | 0.586 | 7 | 5 | 0.527 | 7 | 5 | 0.303 | 3 | 1 | 0.665 | 7 | 5 |
| Incineration: SIP | 0.467 | 3 | 1 | 0.265 | 4 | 2 | 0.579 | 3 | 1 | 0.522 | 3 | 1 | 0.304 | 4 | 2 | 0.658 | 3 | 1 |
| Incineration: moderate | 0.467 | 3 | 1 | 0.265 | 4 | 2 | 0.580 | 4 | 2 | 0.523 | 4 | 2 | 0.305 | 5 | 3 | 0.658 | 3 | 1 |
| Incineration: stringent | 0.468 | 4 | 2 | 0.266 | 5 | 3 | 0.581 | 5 | 3 | 0.524 | 5 | 3 | 0.305 | 5 | 3 | 0.660 | 4 | 2 |
| Waterborne | 0.427 | 2 | N/A | 0.251 | 2 | N/A | 0.487 | 2 | N/A | 0.478 | 2 | N/A | 0.288 | 2 | N/A | 0.562 | 2 | N/A |
| Hot melt (100% solids) | 0.355 | 1 | N/A | 0.238 | 1 | N/A | 0.424 | 1 | N/A | 0.390 | 1 | N/A | 0.271 | 1 | N/A | 0.483 | 1 | N/A |

[a] All calculations were made assuming straight line depreciation of capital equipment over 10 years, a corporate tax rate of 46 percent, an investment tax credit of 10 percent, a discount rate of 16 percent, and that the investment was financed out of retained earnings (no borrowing). Capacity of each line = 5.4 × $10^6$ m². Cost data taken from Table 8-31 using half credit for recovered solvent.

[b] Capacity utilization = 100 percent (based on 6,000 operating hours per year).

[c] Capacity utilization = 75 percent.

[d] Project set A is the unrestricted set, that is, the firm can invest in traditional or alternative coating technologies. Unit costs are ranked from lowest (rank = 1) to highest.

[e] Project set B is the restricted set, that is, the firm cannot invest in the alternative coating technologies (waterborne and hot melt or 100% solids) for technical reasons.

N/A = not applicable.

tandem facilities. Only half the credit for the recovered solvent was allowed for the carbon adsorption lines compared with the full credit allowance for these facilities in Section 8.4.5.1. This increased the profitability of the incineration facilities relative to those using carbon adsorbers, as it did for the large-scale facilities (see Section 8.4.4).

Price impacts are shown in Table 8-43. Given the availability of the alternative technologies, no impact would result under the moderate regulatory alternative. Firms confronted with the constrained project set (B) would incur nominal impacts on the PSA and tandem facilities ranging from 0.0 to 0.2 percent. The SR coating lines would not be affected. Under the stringent control level, there would be no price impact on firms able to utilize the waterborne coating and hot melt technologies. Firms restricted to investments in conventional solvent-based coating techniques (project set B) would have to raise prices from 0.2 to 0.4 percent on the output of PSA lines, from 0.0 to 0.4 percent on the output of SR lines, and 0.3 to 0.4 percent on that of tandem lines.

Table 8-44 gives the ROI impacts of the regulatory alternatives. Firms choosing from project set A would not suffer a decrease in ROI under either the moderate or the stringent control levels. Minor impacts occur when the alternative coating techniques cannot be used. Meeting the moderate control level would entail a loss of 0.0 to 0.1 percentage points in the ROI on investments in PSA and tandem facilities; there are no impacts on SR lines. To comply with the stringent alternative, reductions of 0.2 to 0.3, 0.0 to 0.3, and 0.3 percentage points for the PSA, SR and tandem lines, respectively, would be necessary.

The additional capital investment needed to meet the control levels is also insignificant (and are called for only when the firm must choose a project from set B). Under the moderate alternative, the maximum additional outlay of $5 thousand (for a tandem facility) represents only 0.2 percent of the baseline investment. The maximum incremental investment required by the stringent control level is $23 thousand (also for the tandem line), or 0.8 percent of the initial outlay.

TABLE 8-43. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON MEDIUM FACILITIES (%)[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.19 | 0.21 | 0.38 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.38 | 0.00 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.17 | 0.00 | 0.35 | 0.30 |

[a] Calculated from the costs and rankings in Table 8-42. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the unit cost associated with the configuration is used as the base from which the price impact is calculated.

## TABLE 8-44. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON MEDIUM FACILITIES[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| Baseline ROI | 16.00 | 16.00 | 16.00 | 16.00 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | -0.12 | -0.22 | -0.28 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | -0.26 | 0.00 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | -0.08 | 0.00 | -0.30 | -0.25 |

[a] Table entries represent percentage point decreases in the baseline ROI. Impacts are calculated from the costs and rankings in Table 8-42. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the table entry is the amount by which the baseline ROI of 16 percent must decline to allow the firm to meet the price associated with the line configuration of rank one.

8.4.5.3 Summary of Economic Impacts. The impacts on the medium-scale coating lines are minor and would have little, if any, adverse effects on the growth of the industry attributable to output from these facilities. Neither regulatory alternative would have an impact on new production facilities if firms could invest in the alternative technologies. Firms confronted with project set B would have to raise prices by 0.0 to 0.2 percent to meet the moderate control level and by 0.0 to 0.4 percent to meet the stringent control level. Absorbing all additional costs would reduce the baseline ROI of 16 percent by 0.0 to 0.1 percentage points under the moderate alternative and by 0.0 to 0.3 percentage points under the stringent alternative. The incremental capital required to meet the control levels ranges from 0.0 to 0.8 percent of the baseline investment.

### 8.4.6 Economic Impacts on Small Facilities

This section presents the economic impacts of the regulatory alternatives on small-scale PSA, SR, and tandem production facilities. The impacts in Section 8.4.6.1 are based on the cost data in Table 8-32 with the full credit for recovered solvent allowed for all carbon adsorption lines. Those in section 8.4.6.2 are based on the same data except that only half the recovered solvent credit is allowed. Section 8.4.6.3 summarizes the results.

8.4.6.1 Impacts Based on Full Credit for Recovered Solvent. Table 8-45 presents the unit costs and their associated rankings for all configurations of the small-scale PSA, SR, and tandem facilities. These were used to calculate the price impacts of the regulatory alternatives which are reported in Table 8-46. As this table shows, the availability of alternative technologies (project set A) implies that neither regulatory alternative would have an impact on any production facility.

Restricting the firm's choices to the conventional coating technologies (project set B) would result in some minor impacts. Under the moderate alternative, the tandem facility would have to raise prices by 0.1 percent to maintain the baseline ROI; the PSA and SR facilities would not be affected. The stringent alternative would cause price increases

## TABLE 8-45. UNIT COSTS AND RANKINGS FOR SMALL FACILITIES[a]

| | Scenario 1[b] | | | | | | | | | Scenario 2[c] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSA line | | | SR line | | | Tandem line | | | PSA line | | | SR line | | | Tandem line | | |
| | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | | Cost | Rank | |
| Line configuration | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] | ($/m²) | A[d] | B[e] |
| Adsorption: SIP | 0.775 | 4 | 2 | 0.519 | 3 | 1 | 1.050 | 3 | 1 | 0.905 | 4 | 2 | 0.614 | 3 | 1 | 1.242 | 3 | 1 |
| Adsorption: moderate | 0.774 | 3 | 1 | 0.519 | 3 | 1 | 1.051 | 4 | 2 | 0.904 | 3 | 1 | 0.614 | 3 | 1 | 1.243 | 4 | 2 |
| Adsorption: stringent | 0.775 | 4 | 2 | 0.520 | 4 | 2 | 1.052 | 5 | 3 | 0.906 | 5 | 3 | 0.616 | 4 | 2 | 1.244 | 5 | 3 |
| Incineration: SIP | 0.793 | 5 | 3 | 0.523 | 5 | 3 | 1.071 | 6 | 4 | 0.925 | 6 | 4 | 0.619 | 5 | 3 | 1.265 | 6 | 4 |
| Incineration: moderate | 0.794 | 6 | 4 | 0.523 | 5 | 3 | 1.072 | 7 | 5 | 0.926 | 7 | 5 | 0.619 | 5 | 3 | 1.266 | 7 | 5 |
| Incineration: stringent | 0.797 | 7 | 5 | 0.524 | 6 | 4 | 1.075 | 8 | 6 | 0.930 | 8 | 6 | 0.620 | 6 | 4 | 1.269 | 8 | 6 |
| Waterborne | 0.724 | 2 | N/A | 0.500 | 2 | N/A | 0.957 | 2 | N/A | 0.847 | 2 | N/A | 0.591 | 2 | N/A | 1.146 | 2 | N/A |
| Hot melt (100% solids) | 0.612 | 1 | N/A | 0.465 | 1 | N/A | 0.812 | 1 | N/A | 0.704 | 1 | N/A | 0.547 | 1 | N/A | 0.961 | 1 | N/A |

[a] All calculations were made assuming straight line depreciation of capital equipment over 10 years, a corporate tax rate of 46 percent, an investment tax credit of 10 percent, a discount rate of 16 percent, and that the investment was financed out of retained earnings (no borrowing). Capacity of each line = 1.7 × $10^6$ m². Cost data taken from Table 8-32 using full credit for recovered solvent.

[b] Capacity utilization = 100 percent (based on 6,000 operating hours per year).

[c] Capacity utilization = 75 percent.

[d] Project set A is the unrestricted set, that is, the firm can invest in traditional or alternative coating technologies. Unit costs are ranked from lowest (rank = 1) to highest.

[e] Project set B is the restricted set, that is, the firm cannot invest in the alternative coating technologies (waterborne and hot melt or 100% solids) for technical reasons.

N/A = not applicable.

TABLE 8-46. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON SMALL FACILITIES (%)[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.13 | 0.22 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.19 | 0.33 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.10 | 0.08 | 0.19 | 0.16 |

[a] Calculated from the costs and rankings in Table 8-45. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the unit cost associated with the configuration is used as the base from which the price impact is calculated.

ranging from 0.1 to 0.2 percent for PSA lines, from 0.2 to 0.3 percent for SR lines, and 0.2 percent for tandem lines.

Table 8-47 shows the ROI impacts as percentage point decreases in a baseline ROI of 16 percent. Again, firms confronted with project set A would not be affected by the regulatory alternatives, since they would invest in the alternative technologies even in the absence of a regulation. The impacts on the conventional coating lines are minor. Under the stringent alternative, the ROI for the PSA and tandem lines would decline by 0.1 percentage points and that for the SR line by 0.2 percentage points.

The incremental capital requirements are also modest. For the stringent control level, they range from $5 thousand for the SR facility to $15 thousand for the tandem line, or about 0.7 percent of the baseline capital investment. No additional capital outlays are required if the firm is able to use one of the alternative coating technologies.

8.4.6.2 Impacts Based on Half Credit for Recovered Solvent. Table 8-48 gives the unit costs and rankings for all configurations of the PSA, SR, and tandem facilities. Table 8-49 shows the price impacts of the regulatory alternatives based on these costs and rankings. Firms choosing a project from set A would not be affected by the moderate or stringent alternatives. If waterborne coatings or the hot melt process cannot be used, the moderate control level would cause price increases ranging from 0.1 to 0.2 percent for the tandem facilities; the PSA and SR lines would not be affected. Under the stringent alternative, price increases of 0.2 percent would result for the PSA and SR facilities and of 0.3 to 0.4 percent for the tandem facilities.

Table 8-50 gives the ROI impacts of the moderate and stringent alternatives. There is no impact under either control level if firms can use the alternative technologies. Meeting the moderate control level by absorbing all additional costs would decrease the ROI of the tandem facility by 0.1 percentage points. The stringent alternative would decrease the baseline ROI by 0.1 to 0.2 percentage points for the PSA line, by 0.1 percentage points for the SR line, and by 0.2 percentage points for the tandem line.

TABLE 8-47. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON SMALL FACILITIES[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| Baseline ROI | 16.00 | 16.00 | 16.00 | 16.00 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | -0.09 | -0.13 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | -0.22 | -0.19 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | -0.04 | -0.03 | -0.11 | -0.11 |

[a] Table entries represent percentage point decreases in the baseline ROI. Impacts are calculated from the costs and rankings in Table 8-45. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the table entry is the amount by which the baseline ROI of 16 percent must decline to allow the firm to meet the price associated with the line configuration of rank one.

## TABLE 8-48. UNIT COSTS AND RANKINGS FOR SMALL FACILITIES[a]

| | Scenario 1[b] | | | | | | | | | Scenario 2[c] | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | PSA line | | | SR line | | | Tandem line | | | PSA line | | | SR line | | | Tandem line | | |
| Line configuration | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] | Cost ($/m²) | Rank A[d] | Rank B[e] |
| Adsorption: SIP | 0.790 | 3 | 1 | 0.522 | 3 | 1 | 1.068 | 3 | 1 | 0.921 | 3 | 1 | 0.617 | 3 | 1 | 1.260 | 3 | 1 |
| Adsorption: moderate | 0.790 | 3 | 1 | 0.522 | 3 | 1 | 1.070 | 4 | 2 | 0.921 | 3 | 1 | 0.617 | 3 | 1 | 1.261 | 4 | 2 |
| Adsorption: stringent | 0.792 | 4 | 2 | 0.523 | 4 | 2 | 1.072 | 6 | 4 | 0.923 | 4 | 2 | 0.618 | 4 | 2 | 1.264 | 5 | 3 |
| Incineration: SIP | 0.793 | 5 | 3 | 0.523 | 4 | 2 | 1.071 | 5 | 3 | 0.925 | 5 | 3 | 0.619 | 5 | 3 | 1.265 | 6 | 4 |
| Incineration: moderate | 0.794 | 6 | 4 | 0.523 | 4 | 2 | 1.072 | 6 | 4 | 0.926 | 6 | 4 | 0.619 | 5 | 3 | 1.266 | 7 | 5 |
| Incineration: stringent | 0.797 | 7 | 5 | 0.524 | 5 | 3 | 1.075 | 7 | 5 | 0.930 | 7 | 5 | 0.620 | 6 | 4 | 1.269 | 8 | 6 |
| Waterborne | 0.724 | 2 | N/A | 0.500 | 2 | N/A | 0.957 | 2 | N/A | 0.847 | 2 | N/A | 0.591 | 2 | N/A | 1.146 | 2 | N/A |
| Hot melt (100% solids) | 0.612 | 1 | N/A | 0.465 | 1 | N/A | 0.812 | 1 | N/A | 0.704 | 1 | N/A | 0.547 | 1 | N/A | 0.961 | 1 | N/A |

[a] All calculations were made assuming straight line depreciation of capital equipment over 10 years, a corporate tax rate of 46 percent, an investment tax credit of 10 percent, a discount rate of 16 percent, and that the investment was financed out of retained earnings (no borrowing). Capacity of each line = $1.7 \times 10^6$ m². Cost data taken from Table 8-32 using half credit for recovered solvent.

[b] Capacity utilization = 100 percent (based on 6,000 operating hours per year).

[c] Capacity utilization = 75 percent.

[d] Project set A is the unrestricted set, that is, the firm can invest in traditional or alternative coating technologies. Unit costs are ranked from lowest (rank = 1) to highest.

[e] Project set B is the restricted set, that is, the firm cannot invest in the alternative coating technologies (waterborne and hot melt or 100% solids) for technical reasons.

N/A = not applicable.

## TABLE 8-49. PRICE IMPACTS OF REGULATORY ALTERNATIVES ON SMALL FACILITIES (%)[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.25 | 0.22 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | 0.19 | 0.16 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.19 | 0.08 | 0.37 | 0.32 |

[a] Calculated from the costs and rankings in Table 8-48. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the unit cost associated with the configuration is used as the base from which the price impact is calculated.

TABLE 8-50. RETURN ON INVESTMENT IMPACTS OF REGULATORY ALTERNATIVES ON SMALL FACILITIES[a]

| | Moderate | | Stringent | |
|---|---|---|---|---|
| | Scenario 1 | Scenario 2 | Scenario 1 | Scenario 2 |
| Baseline ROI | 16.00 | 16.00 | 16.00 | 16.00 |
| PSA line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | -0.19 | -0.13 |
| SR line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | 0.00 | 0.00 | -0.11 | -0.11 |
| Tandem line | | | | |
| Project set A | 0.00 | 0.00 | 0.00 | 0.00 |
| Project set B | -0.09 | -0.07 | -0.24 | -0.20 |

[a] Table entries represent percentage point decreases in the baseline ROI. Impacts are calculated from the costs and rankings in Table 8-48. In the absence of a regulation, the firm is assumed to invest in the line configuration with a rank of one. If this configuration meets the control level under consideration, there is no impact. If it does not, the table entry is the amount by which the baseline ROI of 16 percent must decline to allow the firm to meet the price associated with the line configuration of rank one.

The incremental capital requirements to meet the stringent control level are $8 thousand for the PSA line, $5 thousand for the SR line, and $15 thousand for the tandem. These figures represent approximately 0.7 percent of the baseline investment.

8.4.6.3 Summary of Economic Impacts. The regulatory alternatives would have an insignificant impact on the small-scale PSA, SR, and tandem facilities. If firms can use waterborne coatings or the hot melt (100 percent solids) process (project set A), there would be no impact on these facilities. If firms are restricted to the conventional solvent-based coatings (project set B), the moderate alternative would cause price increases ranging from 0.0 to 0.2 percent. The corresponding ROI decreases range from 0.0 to 0.05 percentage points. Price increases ranging from 0.1 to 0.4 percent would result under the stringent alternative. The corresponding ROI impacts would range from a 0.1 to a 0.2 percentage point decline. These impacts are too small to adversely affect the growth of industry output attributable to these sources.

## 8.5 POTENTIAL SOCIOECONOMIC AND INFLATIONARY IMPACTS

Executive Order 12044 requires that the inflationary impacts of major legislative proposals, regulations, and rules be evaluated. The regulatory alternatives would be considered a major action (thus requiring the preparation of an Inflation Impact Statement) if either of the following criteria apply:

1. Additional annualized costs of compliance, including capital charges (interest and depreciation), will total $100 million within any calendar year by the attainment date, if applicable, or within five years of implementation.
2. Total additional cost of production is more than 5 percent of the selling price of the product.

The regulatory alternatives for the pressure sensitive tapes and labels industry would not qualify as a major action by the second criterion, since the largest price increase was estimated to be 0.9 percent (Table 8-37). The remainder of this section is devoted to estimating the total additional cost of compliance with the regulatory alternatives.

The calculations are based on the facility that was most affected by the regulatory alternatives. It was assumed that all future industry output from new sources would come from this facility; thus, if the incremental annualized cost of compliance does not exceed the $100 million threshold, then the regulatory alternatives would not qualify as a major action, since the worst possible impact has been calculated. The facility in question is the large tandem line using an incinerator as the control technique. The incremental annualized cost of compliance for the stringent control level was calculated from the cost data in Table 8-30. The incremental capital investment of $95 thousand was multiplied by a capital recovery factor of 0.207 (based on an interest rate of 16 percent and a 10 year project life) to determine the annualized capital cost. This result, $19.7 thousand, was added to the incremental fixed and variable operating costs of $61 thousand to calculate the incremental annualized cost of compliance, $80.7 thousand per facility.

Next, the difference between forecasted sales in 1980 and 1985 of $1.2 billion was translated into model line equivalents using the following method. The price per square meter of $0.33 (taken from Table 8-36, Scenario 2, tandem incineration facilities) was divided into the projected growth in sales to determine growth in physical output. This quantity was then divided by the capacity of the tandem line (39 million $m^2$ times the capacity utilization rate of 75 percent) to determine the number of lines that would have to be constructed to produce the total projected output. This result, 121 lines, is the transformation of growth in output into "model line equivalents." It was multiplied by the incremental annualized cost of meeting the stringent control level ($80.7 thousand) to estimate the inflationary impact. The incremental cost of compliance was estimated to be $9.8 million, well under the $100 million threshold. Thus, the regulatory alternatives do not meet the criteria specified in the Executive Order and are not a major action requiring the preparation of an Inflation Impact Statement.

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# APPENDIX A

# EVOLUTION OF THE PROPOSED STANDARDS

## Appendix A - Evolution of the Proposed Standards

The purpose of this study was to develop new source performance standards (NSPS) for the pressure sensitive tapes and labels (PSTL) industry. Primarily the study involved gathering and analyzing relevant data in such detail that a reasonable performance standard could be developed, proposed, and defended. To accomplish the objectives of this program, technical data was acquired on the following aspects of the PSTL industry: (1) coating operations and processes, (2) the release and controllability of organic emissions into the atmosphere by this source, and (3) the types and costs of demonstrated control technologies. The bulk of this information was retrieved from the following sources:

- open technical literature
- meeting with specific companies, trade associations, and
- regulatory authorities
- plant visits
- emission source testing

EPA began studying the pressure sensitive tape and label industry in July 1975 as part of a larger study of paper coating operations. Mr. William L. Johnson of EPA made several trips to tape and label manufacturers during the Fall of 1975 and early part of 1976. This work contributed to the 1977 publication of "Control of Volatile Organic Emissions from Existing Stationary Sources - Volume II: Surface Coating of Cans, Coils, Paper, Fabrics, Automobiles and Light-Duty Trucks," EPA-450/2-77-008. This control technique guidelines defined Reasonably Available Control Technology (RACT) for existing paper coating lines. Pressure sensitive tape and label lines were included in this category.

EPA contracted with Springborne Laboratories, Inc. to study major surface coating operations and to determine which operations would be most suitable for NSPS. Springborne visited several paper coaters including one pressure sensitive tape manufacturer in mid 1976. They recommended that industrial paper coating would be an appropriate area for an NSPS.

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In May 1976, Midwest Research Institute (MRI) was hired by EPA to study organic solvent emissions from adhesives users. MRI reported that almost half of the solvent emissions from adhesive use came from the manufacture of pressure sensitive tapes and labels. MRI's study continued until January 1977. It focused on gathering information on the other smaller sectors of the adhesive industry.

Based on the above studies, EPA concluded that paper coating was a major source of solvent emissions and was a source for which control techniques were available. Pressure sensitive tapes and labels made up the largest percentage of emissions of any product within the paper coating category. PSTL was also a distinct group of products for which a well defined economic impact analysis could be performed. For these reasons EPA decided to develop NSPS for the PSTL industry.

In May 1978, Radian Corporation was retained by the EPA to study the PSTL industry in depth and develop an NSPS. The study was performed under EPA Contract Number 68-02-3058. Mr. William L. Johnson functioned as the EPA lead engineer. Mr. G. E. Harris of Radian Corporation assumed primary contractor responsibilities. In January 1979, Mr. T. P. Nelson, also from Radian, took over Mr. Harris' duties. Table A-1 presents the historical progression and major milestones of the project from May 1978 to the present.

In addition to Radian, two other companies also has input to this study. They were Research Triangle Institute (RTI) and Monsanto Research Corporation. RTI, under the EPA direction of Mr. Neil Efird of the Economic Analysis Branch (EAB), prepared the economic impact analysis. Monsanto Research, under the EPA direction of Ms. Nancy McLaughlin of the Emission Measurement Branch (EMB), performed all the emission source testing. At the end of Phase II, Mr. William Tippitt of the Standards Development Branch (SDB) directed the preparation of the regulation and the preamble package for presentation at the Working Group, NAPCTAC, and Steering Committee meetings.

TABLE A-1

| DATE | ACTIVITY |
|---|---|
| May 1978 | 1. Radian work on Pressure Sensitive Adhesives BID begun. |
| | 2. A work plan was formulated and transmitted to EPA. |
| | 3. A kick-off meeting was held to discuss the technical approach, staffing, schedule, and budget. |
| | 4. The literature search was initiated. |
| June 21-22, 1978 | 1. G.E. Harris of Radian attended PSTC Technical seminar on the Use of Emulsion Coating Systems for PSTL Coating. |
| June 29, 1978 | 2. Work on data base is complete. |
| July 27, 1978 | 1. Inspection trip made to Anchor Continental, Inc. in Columbia, S.C. to discuss their coating and control operations. |
| July 28, 1978 | 2. Inspection trip made to Shuford Mills, Inc. in Hickory, N.C. to discuss their coating and control operations. |
| July 31, 1978 | 3. Contacts with control equipment vendors completed. |
| August 29, 1978 | 1. Meeting with 3M Company in St. Paul, Minn. to discuss their input to the PSTL study. |
| October 17, 1978 | 1. Submitted draft BID Chapters 2, 4, and 5 to EPA. |
| November, 1978 | 1. Draft version of Chapter 3 and two technical memornada describing the model plants and test plan were issued. |
| November 30, 1978 | 2. Meeting was held with EPA/OAQPS to discuss transition of PSTL BID from G.E. Harris to T. P. Nelson. |
| December, 1978 | 1. Work completed under EPA contract 68-02-2608 Task 40 was reviewed. |
| | 2. Phase I data base was analyzed. |
| | 3. Technical memoranda concerning a Model IV calculation and the basis for NSPS were issued. |
| January 2, 1979 | 1. T.P. Nelson takes over as Lead Engineer on PSTL BID. |
| January 8, 1979 | 2. Final Work Plan submitted to EPA/OAQPS for Phase II work. |
| January 15, 1979 | 3. Final revised Work Plan submitted for Phase II work. |
| January 16, 1979 | 4. Kick-off meeting held at EPA offices for Phase II work. |
| January 17, 1979 | 5. ESED Project Test Plan submitted to EPA/OAQPS. |
| January 30, 1979 | 6. Initial test request submitted for Shuford Mills site. |
| January 30, 1979 | 7. Meeting held to determine need for EAB and their contractor Research Triangle Institute. |

TABLE A-1 (continued)

| Date | ACTIVITY |
|---|---|
| February 2, 1979 | 1. Meeting was held with EPA to discuss and review final test request for Shuford Mills. |
| February 8, 1979 | 2. Visit to Avery International Offices in San Marino, California. |
| February 9, 1979 | 3. Visit to California Air Resources Board to discuss proposed California rules and the PSTL coating industry. |
| February 14, 1979 | 4. Plant visit to Hard Rubber Co. in New Haven, Connecticut. |
| February 15, 1979 | 5. Plant visit to Tuck Industries in Beacon, New York. |
| February 16, 1979 | 6. Plant visit to Adhesives Research, Inc. in Glen Rock, Pennsylvania. |
| February 28, 1979 | 7. Submit preliminary 8.1 data to RTI. |
| March 1, 1979 | 1. Meeting with T.N. Grenfell of Midland-Ross Air Systems to discuss ovens and air control devices. |
| March 5, 1979 | 2. Submitted revised work plan schedule to ESED. |
| March 7, 1979 | 3. Pretest visit to Shuford Mills, Inc. in Hickory, N.C. |
| March 16, 1979 | 4. Visit to Shell in Houston, Texas to discuss hot melt technology. |
| March 28, 1979 | 5. Visit to Mystic Tape in Northfield, Illinois. |
| March 31, 1979 | 6. Final model plants and final model plant parameters submitted to EPA. |
| April 30, 1979 | 1. Complete cost analysis submitted to EPA (Sections 8.1, 8.2, 8.3). |
| May 4, 1979 | 1. Questionnaire submitted to silicone release sheet manufacturers. |
| May 14-18, 1979 | 2. Monsanto Research Corporation testing of Shuford Mills facility. |
| May 31, 1979 | 3. Revised cost analysis submitted with the inclusion of silicone release sheet coating model plants. |
| June 4-6, 1979 | 1. T.P. Nelson attended TAPPI Conference on Hot Melt Coating technology. |
| June 13-14, 1979 | 2. T.P. Nelson attended PSTC Conference on Water-Based Coating technology. |
| June 15, 1979 | 3. Received preliminary Shuford Mills tests results. |
| June 30, 1979 | 4. Draft BID Chapters 6 and 7 completed and submitted along with the revisions to Chapters 2, 3, 4, and 5. |
| July 12, 1979 | 1. Meeting with American Paper Institute representatives to discuss the involvement of silicone release sheet coaters in the NSPS. |
| July 19, 1979 | 2. Drafts of Chapters 2 through 7 and Sections 8.1, 8.2, and 8.3 are submitted to industry for a technical review. |

TABLE A-1 (continued)

| DATE | ACTIVITY |
|---|---|
| July 23, 1979 | 3. A meeting was held at OAQPS in Durham to discuss preparation of BID Chapter 9 and the preamble package. Radian and EPA personnel were present. A schedule of milestones for project completion was established. |
| August 2, 1979 | 1. Radian submitted draft Sections 9.1 and 9.2 for review. |
| August 8, 1979 | 2. A meeting was held at OAQPS in Durham to discuss the standard concurrence memo. Radian and EPA personnel were present. Agreement was reached on an initial form of the standard. |
| August 10, 1979 | 3. Radian submitted draft Section 9.6 for review. |
| August 17. 1979 | 4. Radian submitted draft Section 9.7 for review. |
| August 22, 1979 | 5. A meeting was held at OAQPS to reexamine the decision reached on the initial standard. EPA and Radian personnel were present. Discussions centered on changing the standard from an equipment or percent reduction standard to an emission limitation. Methods for compliance testing were also discussed. |
| August 28, 1979 | 6. T.P. Nelson of Radian Corp. visited the Precoat Metals coil coating plant in St. Louis, Mo. The purpose of the trip was to see the total enclosure concept for coil coating operations. |
| September 7, 1979 | 1. A meeting was held at OAQPS to finalize the content and form of the concurrence memo for the PSTL standard of performance. The lower emission limit exemption was dropped. |
| September 12, 1979 | 2. T.P. Nelson and G.W. Brooks of Radian Corp. visited the E.J. Gaisser, Inc. zinc oxide paper coating plant in Stanford, Conn. The purpose of this trip was to see the total enclosure concept for paper coating and evaluate its applicability in adhesive coating. |
| October 5, 1979 | 1. A meeting was held at OAQPS between Radian and SDB personnel. It was announced by SDB that Chapter 9 would probably be dropped from the BID. Radian agreed to incorporate all Chapter 9 material into the preamble. |
| October 25, 1979 | 2. A meeting was held at OAQPS with Radian, CPB, SDB, EMB, and EAB personnel present. Final comments on the preamble and regulation were received. The dates for the Working Group and NAPCTAC meetings were given. Radian agreed to have the completed packages finished by November 2, 1979. |

TABLE A-1 (continued)

| DATE | ACTIVITY |
|---|---|
| November 5, 1979 | 1. Radian delivered the Working Group and NAPCTAC packages to EPA. |
| November 15, 1979 | 2. The Working Group meeting was held in Durham, N.C. at OAQPS. Radian presented the development of the NSPS for pressure sensitive tapes and labels. |
| November 20, 1979 | 3. Radian delivered initial docket materials to the EPA. Materials were sent to the EPA Central Docket Section in Washington, D.C. |
| December 13, 1979 | 1. The NAPCTAC Committee meeting was held in Raleigh, N.C. Radian presented the draft NSPS developed for the pressure sensitive tape and label industry. |
| December 19, 1979 | 2. A briefing was held with Mr. Don Goodwin of ESED to explain the Steering Committee package. Radian, CPB, SDB, EMB, and EAB personnel were present. |
| December 20, 1979 | 3. A briefing was held with Mr. Walter Barber of OAQPS to explain the Steering Committee package. Radian, CPB, SDB, EMB, and EAB personnel were present. |
| December 26, 1979 | 4. Radian submitted a draft Action and Transmittal Memo to EPA. |
| December 27, 1979 | 5. Radian submitted revised Action and Transmittal Memos to EPA. |
| December 28, 1979 | 6. The Steering Committee packages were mailed out by EPA. |
| January 11, 1980 | 1. The Steering Committee meeting was held in Washington, D.C. Radian presented an overview of the NSPS for pressure sensitive tapes and labels. |
| February 28, 1980 | 1. A meeting between Radian, EPA, and pressure sensitive tape and label manufacturers was held in Durham, North Carolina. Issues raised by industry at the NAPCTAC meeting were discussed. |
| May 27, 1980 | 1. Draft package for AA Concurrence was submitted to the EPA Lead Engineer. |
| June 2, 1980 | 2. Final AA Concurrence package was delivered to EPA Lead Engineer. The preamble and regulation for proposal, the Action Memo, the Information Memo, and Volume 1 of the BID were included in the package. |

## APPENDIX B

## INDEX TO ENVIRONMENTAL IMPACT CONSIDERATIONS

A reference system cross-indexed with the October 21, 1974, Federal Register (39 FR 37419) containing the Agency guidelines concerning the preparation of Environmental Impact Statements for regulatory actions is presented. With this index, anyone interested in reading those sections of the Background Information Document that contain discussions of any data and information germane to any portion of the Federal Register guidelines is directed to the appropriate subsections and pages within the document. An example of this cross-indexed reference system is included in this outline.

## Example of Cross-Indexed Reference System to Highlight Environmental Impact Portions of the Document

| Agency Guidelines for Preparing Regulatory Action Environmental Impact Statements (39 FR 37419) | Location Within the Background Information Document |
|---|---|
| (1) Background and summary of regulatory alternatives | The regulatory alternatives from which standards will be chosen for proposal are summarized in Chapter 1, section 1.1, page 1-1. |
| Stautory basis for proposing standards | The statutory basis for proposing standards is summarized in Chapter 2, section 2.1, pages 2-1 through 2-5. |
| Relationship to other regulatory agency actions | The various relationships between the regulatory agency actions are discussed in Chapters 3, 7, and 8. |
| Industry affected by the regulatory alternatives | A discussion of the industry affected by the regulatory alternatives is presented in Chapter 3, section 3.1, pages 3-1 through 3-3. Further details covering the "business/economic" nature of the industry is presented in Chapter 8, section 8.1, pages 8-1 through 8-41. |
| Specific processes affected by the regulatory alternatives | The specific processes and facilities affected by the regulatory alternatives are summarized in Chapter 1, section 1.1, page 1-1. A detailed technical discussion of the sources and processes affected by the regulatory alternatives is presented in Chapter 3, section 3.2, pages 3-3 through 3-36. |

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# APPENDIX C

# EMISSION SOURCE TEST DATA

# APPENDIX C
# EMISSION SOURCE TEST DATA

The emission source test data for the pressure sensitive tape and label (PSTL) BID comes from three sources:

(1) Existing test data on PSTL coating facilities,
(2) U. S. Environmental Protection Agency sponsored testing, and
(3) Material balance data from solvent-based coating lines equipped with carbon adsorption VOC control units.

The following sections discuss this data.

## Existing Test Data on PSTL Coating Facilities

The only source test data on controlled PSTL coating facilities came from the state of California. These tests were performed at Avery Label Company in Monrovia, California, and Fasson Products Division of Avery Corporation in Cucamonga, California. Table C-1 summarizes the data from these tests. Testing was only completed around the control device (as specified by California law). There were no attempts to complete material balances.

## U.S. Environmental Protection Agency Testing

In May 1979, the U.S. Environmental Protection Agency sponsored testing of a 1.52 meter (60-inch) wide tandem pressure sensitive tape coater. The facility was totally dedicated to the production of masking tape. The machine coated in series a release backside and an adhesive front side on a continuous crepe paper backing. The coating line has a separate coating applicator and drying/curing oven for each coating operation. Figure C-1 illustrates the tandem coater.

The VOC emissions from the release coating oven are controlled by an incineration unit, while emissions from the adhesive oven are controlled by a carbon adsorption unit. The incinerator supplies all the heat energy required in the release drying/curing oven. At full capacity the solvent burned in the incinerator supplies approximately 50 percent of the total system heat load. The remaining fuel requirements are supplied by number 2 fuel oil. The carbon adsorption unit recovers

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TABLE C-1. CALIFORNIA SOURCE TEST DATA

| | Tests at Avery Label Co. Monrovia, California | | | Tests at Fasson Company Cucamonga, California | |
|---|---|---|---|---|---|
| Test No. | C-2236 | C-2236 | C-2273 | NR | NR |
| Date | 3/18/75 | 3/18/75 | 8/20/75 | 1/26/72 | 1/26/72 |
| Incinerator temperature $^{o}C$ ($^{o}F$) | 815 (1500) | 804 (1480) | 788 (1450) | 760 (1400) | 746 (1375) |
| Inlet organic conc.* (ppm, dry) | 9180 | 14,400 | 28,700 | 7867 | 8400 |
| Inlet flowrate, $Nm^3$/sec. (scfm, dry) | 1.69 (3790) | 5.93 (13,300) | 12.6 (28,700) | 3.11 (6982) | 4.13 (9261) |
| Inlet temperature $^{o}C$ (oF) | 29 (85) | 34 (93) | NR | NR | NR |
| Outlet organic conc.* (ppm, dry) | 92 | 134 | 764 | 108 | 175 |
| Outlet flowrate, $Nm^3$/sec. (scfm, dry) | 1.63 (3660) | 5.75 (12,900) | 12.1 (27,200) | 3.11 (6982) | 4.13 (9261) |
| Outlet temperature $^{o}C$ ($^{o}F$) | 815 (1500) | 804 (1480) | 787 (1450) | 760 (1400) | 746 (1375) |
| Percent VOC reduction | 99.0 | 99.1 | 97.4 | 98.6 | 97.9 |

NR = Not Reported

* Organic concentration measurements made by flame ionization.

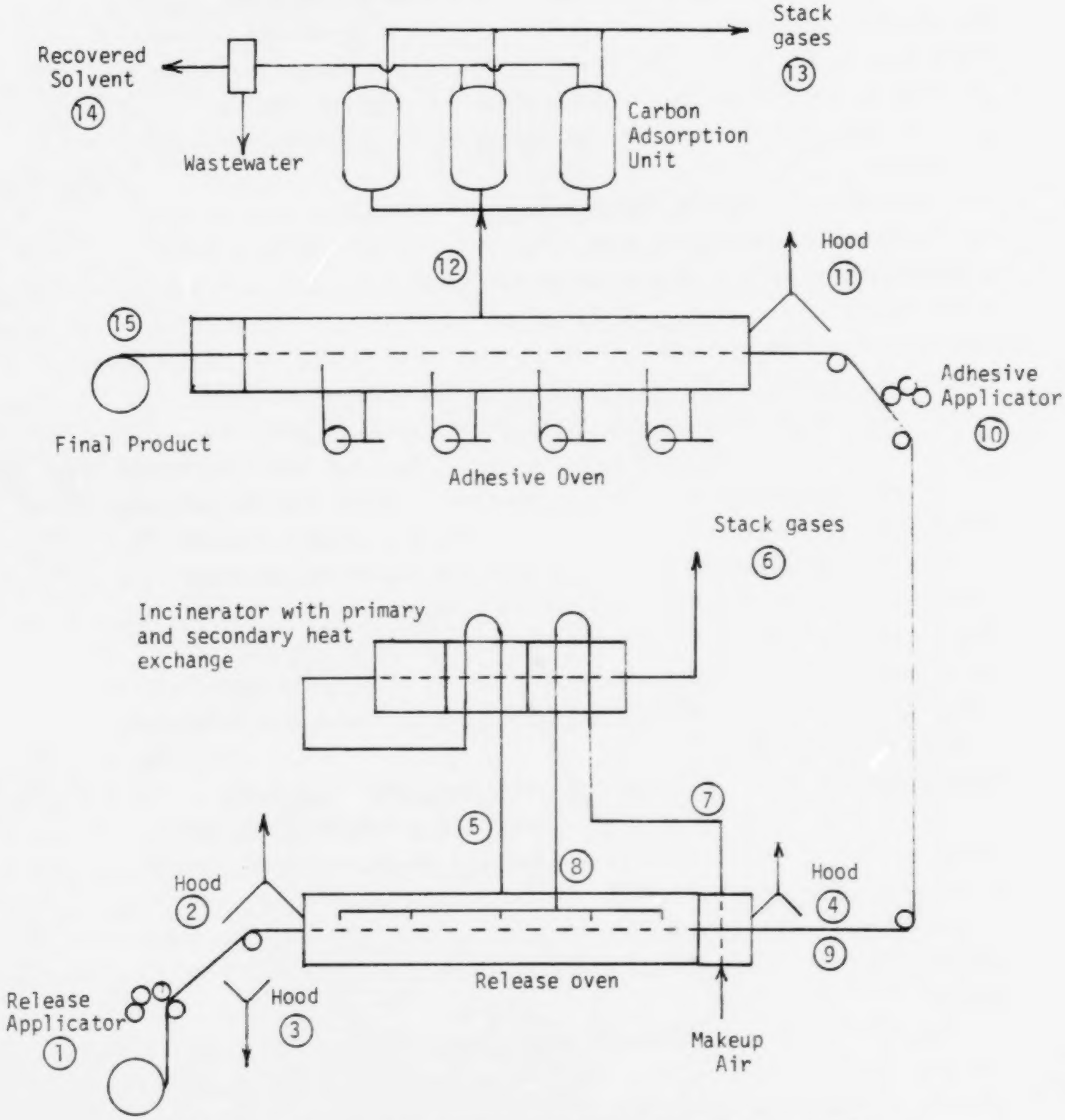
Stack gases
13
Recovered Solvent
14
Wastewater
Carbon Adsorption Unit
Hood
11
12
15
Adhesive Applicator
10
Final Product
Adhesive Oven
Stack gases
6
Incinerator with primary and secondary heat exchange
7
5
8
Hood
2
Hood
4
9
Release Applicator
1
Hood
3
Release oven
Makeup Air

Figure C-1. Tandem coating facility with add-on controls.

nearly 90 percent of the solvents used in the applied adhesives. All of the recovered solvent is reused on-site. For fugitive solvent control there is a hooding system over and under the release coater area, over the exit of the release drying/curing oven, and over the adhesive coating area. All of these hooding systems are vented directly to the atmosphere.

Separate tests were performed around the release/incinerator line and the adhesive/carbon adsorption line. The release coating contains approximately 42 weight percent solids and the applied coating weight is 0.0071 kg per square meter (0.21 ounce per square yard). The adhesive coating contains approximately 57 weight percent solids and the applied coating weight is 0.039 kg per square meter (1.15 ounces per square yard). The results of the source tests are presented in Table C-2. (Note: At the time of this printing the results have not been finalized.)

A material balance could not be completed around either the release/ incinerator system nor the adhesive/carbon adsorber system. Inaccuracies in flow measurements and VOC analyses are considered the major problems. One of the major results of the study was the verification that hooding systems can effectively collect fugitive solvents around the coater areas. The concentration of solvents in the hood gases around the coating applicator ranged from 3,000 to 14,000 vppm (measured as c, by Reference Method 25).

## Material Balance Data for Carbon Adsorption Controlled Facilities

Carbon adsorption controlled coating lines provide a unique opportunity to examine the overall VOC control performance of a total system without requiring testing. The metering and measurement of the total solvents used in formulations and the total solvent recovered from the carbon adsorption system give an exact measurement of the overall VOC capture.

One such facility was examined over a four week period of time (January 15, 1979 to February 9, 1979). The facility consists of four adhesive coating lines controlled by a single carbon adsorption system. The four lines consist of three 28" wide lines and one 56" wide line. The plant operation is characterized by many short runs at slow line

## TABLE C-2. TEST RESULTS FOR EPA SPONSORED TESTING

| Site number[a] | | Measured solvent concentration[b] (Vppm as $C_1$) | Measured gas flowrate[c] $Nm^3$/sec (scfm) | Measured solvent rate, kg/min (lb/min) |
|---|---|---|---|---|
| 1 | Solvent in release coating | | | 2.3 (5.2) |
| 2 | Hood over release coater | 13,990 | 1.38 (3,090) | |
| 3 | Hood under release coater | 6,075 | 0.44 (980) | |
| 4 | Hood over release oven exit | 701 | 0.80 (1,800) | |
| 5 | Incinerator feed | 19,537 | 1.29 (2,900) | |
| 6 | Incinerator stack gases | 6,140 | 2.30 (5,160) | |
| 7 | Cool makeup air | 7,093 | 1.48 (3,310) | |
| 8 | Heated makeup air | 7,520 | 1.66 (3,716) | |
| 9 | Release product | | | Not reported |
| 10 | Solvent in adhesive coating | | | 7.0 (15.5) |
| 11 | Hood over adhesive coater | 2,996 | 1.92 (4,310) | |
| 12 | Carbon adsorber feed | 11,410 | 17.0 (38,100) | |
| 13 | Carbon adsorber stack gases | 1,330 | 17.6 (39,400) | |
| 14 | Recovered solvent | | | 6.8 (15.0) |
| 15 | Final adhesive product | | | 0.07 (0.16) |

[a] Refers to sites in Figure C-1.

[b] Measured by Reference Test Method 25. Value represents the average of three tests.

[c] Measured as specified by Reference Test Methods 1 through 4.

speeds. Table C-3 summarizes the operations of each line and the total system. This facility is a good example of a hard to control facility in that this study has indicated that slow coating lines are the most difficult to control (e.g., they have the greatest potential for fugitive solvent emissions).

During the four week test period, the controlled facility used 7,589 gallons of solvents in their adhesive formulations and recovered 7,065 gallons from the carbon adsorption facility. This represents an overall VOC control of 93.1 percent. The system performed 140 separate runs and used the following solvents: toluene, acetone, hexane, ethyl acetate, methyl ethyl ketone, rubber solvent, heptane, mixed solvents, recovered pro lam solvents, xylene, ethyl alcohol, and isopropanol.

The excellent performance of this system can be potentially attributed to the unique way the system is operated. The makeup air for the ovens is pulled directly from the work area. The building which houses the coaters is tight enough to allow a slight negative pressure in the work area as compared to the outside of the building. Also, the coater ovens are operated with a slight negative pressure with respect to the room air. With a fully enclosed, tight system, the overall result is for all makeup air to flow into the building, through the oven, and out to the carbon adsorption system. This means essentially 100 percent capture of all solvent emissions. The facility also uses hoods over the coater areas to capture fugitive solvent emissions near the coating applicator. The hood gases are ducted into the drying oven.

A second pressure sensitive tape coating facility controlled by carbon adsorption reported to EPA historical solvent recovery data for the entire year of 1979. Total solvent use, total solvent recovery, and the overall recovery percentage were reported on a weekly basis. A summary of the control percentages is given in Table C-4. For most of the year the solvent recovery percentage is 90 percent or better in both the weekly and monthly (4 week) bases. In the latter third of the year the overall control percentage starts to go down below 90 percent. This decline is directly attributable to the old carbon in the carbon adsorption system. The carbon had originally been installed in

TABLE C-3. SUMMARY OF COATING LINE OPERATIONS

| Line number | Line width, m (inches) | Number of runs | Average line speed, m/sec (fpm) | Average weight percent solvent | Total solvent used* |  |
|---|---|---|---|---|---|---|
|  |  |  |  |  | kg (pounds) | liters (gallons) |
| 1 | 1.42 (56) | 25 | 0.21 (41) | 57.5 | 12,750 (28,110) | 15,630 (4,129) |
| 2 | 0.71 (28) | 68 | 0.24 (46.5) | 62.2 | 4,915 (10,837) | 5,761 (1,522) |
| 3 | 0.71 (28) | 23 | 0.24 (46.5) | 66.0 | 3,747 (8,262) | 4,323 (1,142) |
| 4 | 0.71 (28) | 24 | 0.22 (42.5) | 62.4 | 2,309 (5,091) | 3,017 (797) |
| Total |  | 140 | 0.23 (44.8) | 60.3 | 23,723 (52,300) | 28,731 (7,589) |

*Measured during the four week test period.

TABLE C-4. OVERALL CONTROL EFFICIENCY FROM TAPE PLANT USING CARBON ADSORPTION

| Week of | Overall Control Efficiency | 4 Week Average |
|---|---|---|
| 1/6/79 | 94.9 | - |
| 1/13/79 | 97.8 | - |
| 1/20/79 | 95.5 | - |
| 1/27/79 | 95.0 | 95.8 |
| 2/3/79 | 96.0 | - |
| 2/10/79 | 91.3 | - |
| 2/17/79 | 91.0 | - |
| 2/24/79 | 93.8 | 93.0 |
| 3/3/79 | 92.6 | - |
| 3/10/79 | 94.4 | - |
| 3/17/79 | 95.5 | - |
| 3/24/79 | 94.1 | 94.2 |
| 3/31/79 | 91.9 | - |
| 4/7/79 | 98.9 | - |
| 4/14/79 | 84.4 | - |
| 4/21/79 | 96.1 | 92.8 |
| 4/28/79 | 90.3 | - |
| 5/5/79 | 87.0 | - |
| 5/12/79 | 89.5 | - |
| 5/19/79 | 98.9 | 91.4 |
| 5/26/79 | 81.6 | - |
| 6/2/79 | 95.1 | - |
| 6/9/79 | 88.7 | - |
| 6/16/79 | 93.0 | 89.6 |
| 6/23/79 | 81.1 | - |

## TABLE C-4. (Cont.) OVERALL CONTROL EFFICIENCY FROM TAPE PLANT USING CARBON ADSORPTION

| Week of | Overall Control Efficiency | 4 Week Average |
|---|---|---|
| 7/7/79 | 89.6 | - |
| 7/14/79 | 96.9 | - |
| 7/21/79 | 97.0 | 91.2 |
| 7/28/79 | 94.8 | - |
| 8/4/79 | 92.0 | - |
| 8/11/79 | 87.2 | - |
| 8/18/79 | 87.0 | 90.3 |
| 8/25/79 | 78.7 | - |
| 9/1/79 | 81.8 | - |
| 9/8/79 | 91.1 | - |
| 9/15/79 | 88.0 | 84.9 |
| 9/22/79 | 86.7 | - |
| 9/29/79 | 77.3 | - |
| 10/6/79 | 89.9 | - |
| 10/13/79 | 88.3 | 85.6 |
| 10/20/79 | 85.3 | - |
| 10/27/79 | 89.0 | - |
| 11/3/79 | 86.0 | - |
| 11/10/79 | 85.0 | 86.3 |
| 11/17/79 | 88.0 | - |
| 11/24/79 | 90.1 | - |
| 12/1/79 | 92.1 | - |
| 12/8/79 | 79.9 | 87.5 |
| 12/15/79 | 87.2 | - |
| 12/31/79 | 87.2 | - |

March of 1977. The expected life of the carbon bed was estimated at 2 to 2½ years. Consequently, new carbon should have been added in mid-1979. Because it was not, the control percentages started to degrade.

In January of 1980 new carbon was installed in the carbon adsorption system. The overall control percentage went up immediately upon installation of the new carbon. Ninety percent control and greater has been attained consistently since the changeover. Recovery data since the new carbon was added is given in Table C-5. The model plant analysis in Chapter 6 assumed a carbon life of two years. This data supports that assumption and the contention that ninety percent overall control is an attainable control level for this industry.

TABLE C-5. OVERALL CONTROL EFFICIENCY SINCE CHANGEOVER TO NEW CARBON

| Week of | Overall Control Efficiency | 4 Week Average |
|---|---|---|
| 1/7/80 | 90.8 | - |
| 1/14/80 | 99.9 | - |
| 1/21/80 | 92.5 | - |
| 1/28/80 | 88.0 | 92.8 |
| 2/4/80 | 94.4 | - |
| 2/11/80 | 99.2 | - |
| 2/18/80 | 86.1 | - |
| 2/25/80 | 96.3 | 94.0 |
| 3/3/80 | 98.3 | - |
| 3/10/80 | 96.4 | - |
| 3/17/80 | 96.2 | - |
| 3/24/80 | 92.8 | 95.9 |
| 3/31/80 | 91.2 | - |
| 4/10/80 | 93.1 | - |

# APPENDIX D: EMISSION MEASUREMENT AND MONITORING

# APPENDIX D - EMISSION MEASUREMENT AND MONITORING

## D.1 EMISSION MEASUREMENT METHODS

During the standard support study for the pressure sensitive tapes and labels (PSTL) industry, the Environmental Protection Agency conducted tests for volatile organic compounds (VOC) at one plant. Two lines were tested, one controlled by a carbon adsorber and the other by an incinerator. There were several purposes for the testing: determination of the control efficiency across the carbon adsorber and incinerator; determination of the effectiveness of the hooding by measuring the amount of fugitive VOC captured and vented by each hood; and determination of a solvent material balance for each coating line.

Stack tests were performed at ten sites to measure the VOC mass flow rate. The sampling locations were selected according to EPA Reference Method 1. Reference Method 2 was used to determine the volumetric flow rate. Molecular weight of the gas stream was determined according to Method 3, and moisture was determined by either Method 4 or a standard wet bulb/dry bulb procedure. Methods 2, 3, and 4 were combined to calculate the dry standard volumetric flow rate.

The VOC concentration in each stack was determined using two of three different methods:

1. Proposed Reference Method 25, "Determination of Total Gaseous Nonmethane Organic Emissions as Carbon (TGNMO)."
2. Integrated bag samples analyzed by a flame ionization analyzer (BAG/FIA)[1].

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3. Continuous concentration measurements using direct extraction and a flame ionization analyzer (FIA)[2].

At eight sites, the TGMNO and BAG/FIA methods were run simultaneously. These testing sites were either in explosive atmospheres or remote locations. At the other two sites, carbon adsorber inlet and outlet, the TGNMO and the direct extraction FIA methods were used. The direct FIA was used instead of the integrated bag sample FIA method because these sites were not in hazardous areas, and with the continuous FIA minor process variations could be noted. The results from the two FIA methods should be equivalent. The FIA was calibrated with propane.

At each site, the VOC measurements were performed for three 45-minute runs with volumetric flow measurements being made before and after each VOC run. As much as possible, the three replicate runs were made when the same tape product was being produced, and when the process was operating normally. During the testing period, several process parameters were recorded including amount of solvent used, amount of solvent recovered by the carbon adsorber, and incinerator temperature.

Periodically, intermediate and final tape samples were collected and analyzed for residual solvent, using ASTM F 151-72 "Standard Test Method for Residual Solvents in Flexible Barrier Materials." This method provided only an index for comparing solvent levels and was inappropriate for the true measurement of residual solvent.

Samples of the solvents were obtained and analyzed for speciation by direct injection into a gas chromatograph. Samples of the coatings were obtained and analyzed for weight percent solvent. The samples were diluted with more solvent and analyzed by direct injection into a gas chromatograph.

## D.2 PERFORMANCE TEST METHODS

For the standard for the pressure sensitive tapes and labels industry, performance test methods are needed in two areas: determination of the solvent content of the coating; and determination of the overall control efficiency of the add-on pollution control system. Furthermore, the test method for control efficiency is different depending on the type of add-on control device used.

### D.2.1 Analysis of Coatings

D.2.1.1 Volatile Organic Compound Content of the Coating. For the proposed PSTL regulation the organic content of the coating needs to be determined in units of mass of volatile organic compounds per mass of coating solids. This value may be obtained either from the coating manufacturer's formulation or from a modified version of proposed Reference Method 24, "Determination of Volatile Organic Content (as Mass) of Paint, Varnish, Lacquer, or Related Products."

Reference Method 24 combines several ASTM standard methods which determine the volatile matter content, density, volume of solids, and water content of the paint, varnish, lacquer, or related coating. From this information, the mass of volatile organic compounds (VOC) per unit volume of coating solids is calculated. A detailed description of the rationale leading to the selection of this method is presented in another EPA document.[3]

Because the proposed PSTL regulation for coatings is in different units, Reference Method 24 must be modified so its results are in the same units as the standard. This actually simplifies the test method by eliminating some steps. For non-aqueous coatings (solvent-reducible coatings), the procedure to be used is ASTM D 2369-73, "Standard Test Method for Volatile Content of Paints." For coatings with water (water-reducible coatings), the previously mentioned procedure (ASTM D 2369-73) is combined with another procedure which determines the water content of the coating. There are two acceptable procedures for this, ASTM D 3792, "Standard Test Method for Water in Water Reducible Paint by Direct Injection into a Gas Chromatograph," and as ASTM draft "Standard Test Method for Water in Paint or Related Coatings by the Karl Fischer Titration Method." The results from these procedures are the non-aqueous volatile content of the coating (as a weight fraction) and the water content (as a weight fraction). From these procedures the weight fraction solids content in the coating can also be determined. To obtain the VOC content of the coating in the units specified in the regulation, the weight fraction non-aqueous volatiles is divided by the weight fraction solids, giving the result in mass of VOC per mass of coating solids.

The estimated cost of analysis per coating sample is $50 for the total volatile content procedure (ASTM D 2369-73). For aqueous coatings, there is an additional $100 per sample for water content determination. Because the testing equipment is standard laboratory apparatus, no additional purchasing costs are expected.

D.2.1.2 Density of the Coating. For the proposed PSTL regulation the density of the coating may need to be determined. This value may be obtained either from the coating manufacturer's formulation or from a procedure in proposed Reference Method 24. The procedure to be used is ASTM D 1475-60, "Standard Test Method for Density of Paint, Varnish, Lacquer, and Related Products."

The estimated cost of analysis per coating sample is $25. Because the testing equipment is standard laboratory apparatus, no additional purchasing costs are expected.

### D.2.2 Efficiency of the Pollution Control System

If the amount of solvent in the coatings exceeds the standard, then the overall efficiency of the entire vapor control system must be determined. The overall efficiency is determined by comparing the amount of solvent controlled (either recovered or destroyed) to the potential amount of solvent emitted with no controls. It should be noted that the overall system control efficiency is not the same as the efficiency of the individual vapor control device, because the overall efficiency considers the fugitive emissions that are not routed to the device.

D.2.2.1 Carbon Adsorber Test Procedure. For carbon adsorbers, performance is demonstrated by comparing the solvent used versus the solvent recovered. In using a solvent inventory system, it is necessary to monitor two things: the amount of solvent used; and the amount of solvent recovered by the carbon adsorption system. To determine the efficiency of the carbon adsorber system, these data should be collected over a period of one month. This time interval allows the test to be run using a representative variety of coatings and tape products, as well as reducing the impact of variations in the process that would otherwise affect the representativeness of a short-term test. It should be noted that this procedure determines the overall control efficiency based on the original amount of solvent used, not the amount entering the carbon adsorber, and fugitive emissions are allowed as long as the overall control efficiency meets the standard.

The cost of such a performance test should be minimal because the solvent inventory data would probably be monitored anyway by the plant. If not, the estimated purchase cost of two accurate liquid weight meters is $1400.

D.2.2.2 Incinerator Test Procedure. Because incinerators destruct the solvent rather than recover it, a different type of performance test is needed. The recommended procedure measures the mass of VOC (as carbon) in the incinerator system vents (incinerator inlet, incinerator outlet, and fugitive emission vents), and determines the overall control efficiency of the system.

The recommended procedure for determining the mass of VOC (as carbon) in the incinerator system vents uses a combination of several standard methods. EPA Reference Method 1 is used to select the sampling site. Reference Method 2 measures the volumetric flow rate in the vent, while Methods 3 and 4 measure the molecular weight and moisture content to adjust the volumetric flow to dry standard conditions. The VOC concentration in the vent is measured by proposed Reference Method 25, "Determination of Total Gaseous Nonmethane Organic Emissions as Carbon (TGNMO)." The results from these methods are combined to give the mass of VOC (as carbon) in the vent.

Three one-hour runs of Reference Method 25 are recommended for a complete test, with Reference Methods 2, 3, and 4 being performed at least twice during that period. Measurements at the inlet, outlet, and fugitive emission vents should be performed simultaneously. Although the actual testing time using Reference Method 25 is only 3 hours, the total time required for one complete performance test is estimated at 8 hours, with an estimated overall cost of $4,000, plus $2,000 for each fugitive vent measured. During the performance test, the process should be operating normally. Because this is a short-term test, the enforcement agency should consider the solvents and coatings being used to ensure representativeness.

The TGNMO method was selected to measure the VOC concentration instead of one of the other methods discussed in Section D.1 "Emission Test Methods." It is simpler to use, especially in explosive atmospheres or when sampling high-temperature, moist streams. Also, because the detector used in Reference Method 25 measures all the non-methane organics as methane, all carbon atoms give an equivalent instrument response. Therefore, the problem of varying response ratios for different organic compounds (typical of all flame ionization units) is avoided. A more detailed discussion of the TGNMO method and its advantages is presented in another EPA document[3].

D.2.2.3 Comparison of Test Procedures. The decision to recommend two different performance test methods was made after considering several factors. It is usually preferable to have the same performance test method regardless of the type of control device. In this case, the stack sampling procedure described for incinerators is also applicable to carbon adsorbers. However, the solvent inventory method is a far more practical and accurate procedure. It is very inexpensive, requires no special technical sampling and analytical procedures, and has a test period of one month, so that a representative variety of coatings can be tested. Unfortunately, an inventory-type method cannot be applied to incinerators. The one-day TGNMO inlet and outlet stack test procedure is the best method for testing incinerators, but this method would become exorbitantly expensive and impractical if a longer test period were required. Thus, it was decided that the advantages of the solvent inventory-type test for carbon adsorbers outweigh the disadvantages of having two different performance test methods with two different test periods.

There are important differences between the carbon adsorber and incinerator test procedures that should be noted. The test procedure for the carbon adsorber system relates the original amount of solvent used at the coating head to the amount of solvent controlled, i.e. recovered, by the adsorber. It is possible to compare the two amounts because the same measurement method is used, (liquid solvent used versus liquid solvent recovered). However, for incinerator systems, the amount of solvent used should not be directly related to the amount of solvent controlled, i.e.

destructed, because different measurement procedures are used, (solvent used is measured as a liquid, while solvent destructed is measured as gaseous VOC). Thus, for incinerators, the amount controlled is determined by using the amount of VOC measured in the inlet vent versus the outlet vent. The overall incinerator system control efficiency is determined by relating the amount destructed to all the potential uncontrolled emissions. To make the incinerator test procedure equivalent to the carbon adsorber test procedure, one must be able to measure all the potential emissions, both fugitive emissions and oven emissions ducted into the incinerator. That is, all fugitive VOC emissions from the web coating area must be captured and vented through stacks suitable for testing. The alternatives are to completely enclose the coating area within the plant, or to construct the facility so that the building ventilation system captures all the fugitive emissions and ducts them into a testable stack.

## D.3 MONITORING SYSTEMS AND DEVICES

The purpose of monitoring is to ensure that the emission control system is being properly operated and maintained after the performance test. One can either directly monitor the regulated pollutant, or instead, monitor an operational parameter of the emission control system. The aim is to select a relatively inexpensive and simple method which will indicate that the facility is in continual compliance with the standard.

For carbon adsorption systems, the recommended monitoring test is identical to the performance test. A solvent inventory record is maintained, and the control efficiency is calculated every month. Excluding reporting costs, this monitoring procedure should not incur any additional costs for the affected facility, because these process data are normally recorded anyway, and the liquid weight meters were already installed for the earlier performance test.

For incinerators, two monitoring approaches were considered: (1) directly monitoring the VOC content of the inlet, outlet, and fugitive vents so that the monitoring test would be similar to the performance test; and (2) monitoring the operating temperature of the incinerator as an indicator of compliance. The first alternative would require at least two continuous hydrocarbon monitors with recorders, (about $4,000 each), and frequent calibration and maintenance. Instead, it is recommended that a record be kept of the incinerator temperature. The temperature level for indication of complicance should be related to the average temperature measured during the performance test. The averaging time for the temperature for monitoring purposes should be related to the time period for the performance test, in this case 3 hours. Since a temperature monitor is usually included as a standard feature for incinerators, it is expected that this monitoring requirement will not incur additional costs for the plant. The cost of purchasing and installing an accurate temperature measurement device and recorder is estimated at $1,000.

## D.4 REFERENCES

1. Feairheller, W. F., "Measurement of Gaseous Organic Compound Emissions by Gas Chromatography," Monsanto Research Corporation, prepared under EPA Contract No. 68-02-2818, January 1978.

2. "Alternative Test Method for Direct Measurement of Total Gaseous Organic Compounds Using a Flame Ionization Analyzer," in "Measurement of Volatile Organic Compounds," OAQPS Guideline Series, EPA Report No. 450/2-78-041, October 1978.

3. "Automobile and Light-Duty Truck Surface Coating Operations - Background Information for Proposed Standards," EPA Report No. 450/3-79-030, September 1979.